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STANGERIA PARADOXA

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(WITH PLATES XXIV–XXVI AND ONE FIGURE)

Stangeria is the most fernlike of all the cycads; in fact it was described originally as a species of *Lomaria*, one of the Polypodiaceae, and the mistake was not corrected until the cones were discovered. The genus may be monotypic, with *Stangeria paradoxa* as its single polymorphic species. That its general habit, as it appears in the field, is extremely variable is beyond question; and that under cultivation in conservatories and botanical gardens it becomes quite different from the wild form is also apparent.

A plant called *Stangeria eriopus* in the New York Botanical Garden has produced fine crowns of leaves, surpassing anything one is likely to find in the field, and it has had at least one ovulate cone (10). A specimen of *S. paradoxa* in the Botanic Garden at Sydney, Australia, had in 1911 a fine display of leaves and 8 staminate cones; while another plant in the same garden had 5 ovulate cones and an equally fine display of leaves. In the Sydney plants the leaves were not in a single crown, but on subterranean branches with only a few leaves on a branch. In both the Australian and the African gardens *Stangeria* produces leaves and cones more freely than in the field, and both cones and leaves are larger than in field specimens. The cultivated specimens are more beautiful and luxuriant, and differ so much from plants in the field, that some

observers might make new species of them. In the Botanical Garden at Durban, South Africa, Mr. WYLIE showed me a vigorous *Stangeria* with leaves a meter long. The leaflets were 45cm. long, and so deeply incised that they were almost pinnate. Some taxonomists, doubtless, would regard this plant as a distinct species. In *Dioon* and *Bowenia* the character of the leaf margin is so rigidly fixed and so persistently transmitted from one generation to another that it is entitled to rank as a specific character; but in *Stangeria* the character of the margin is so fluctuating that even the almost bipinnate Durban plant should not be regarded as specifically different from forms with entire leaflets.

Field observations

My field observations on *Stangeria* began at Ngoye, near Mtunzini in Zululand, about 100 miles north of Durban, and extended to East London, about 275 miles south of Durban. *Stangeria* certainly extends farther north, just how much farther I was not able to determine; and its western limit is west of East London. I did not find it at Port Elizabeth, about 150 miles west of East London, or even at Grahamstown, or Trapps Valley, about half-way between East London and Port Elizabeth; but Mr. GEORGE RATTRAY, of Selborn College, East London, has reported it from Port Elizabeth, and he regards this as about the western limit of its range. His extensive knowledge of South African cycads in the field enables him to speak with authority upon their geographical distribution.

In the field, *Stangeria* presents two forms, one growing on the open grass veldt and the other in the shade of bushes or trees, the shaded form being much larger and resembling more nearly the cultivated specimens. PEARSON (9) has contrasted the two forms as *Stangeria paradoxa*, the species originally described from the shaded Natal form, and *Stangeria* sp., the open grass veldt form; but he had seen both forms in the field, and consequently hesitated to give a specific name to the second form. RATTRAY, who lives in a *Stangeria* region, and who has studied the genus throughout its range, believes there is only one species. Before I left South Africa, I had come to the same conclusion. I dug up

several plants from the East London grass veldt and sent them to our greenhouse at the University of Chicago, where after three years of the usual unnatural conditions they are producing leaves and cones as large as those of the bush veldt form.

Near Mtunzini in Zululand the grass veldt stretches for miles, rolling and hilly, broken by huge rocks of granite and gneiss, and

FIG. 1.—*Stangeria paradoxa* growing in the grass veldt at Ngoye, near Mtunzini, Zululand.

occasionally with exposed surfaces covered only with *Selaginella* and lichens. The grass is 30–40 cm. high, and appearing above it are the leaves of *Stangeria* (fig. 1). The leaves are larger and more numerous than in the East London district, three or four leaves being common, and some stems having fine crowns of five or six leaves.

The plants are fairly abundant, as many as 20 being in sight at one time; but the specimens are scattered, with no crowded masses like the thickets of *Macrozamia spiralis* and *Bowenia serrulata* in Australia. Although adult plants are numerous, cones are

rare. At the time of my visit, the middle of January, 1912, the staminate cones had rotted or dried up, and the ovulate cones were falling to pieces. The few seeds which were secured showed embryos in early suspensor stages.

In the Mtunzini bush, which is particularly dense and rich in ferns, only a few plants of *Stangeria* were seen, but they were vigorous, with three or four leaves about twice the size of those in the open grass veldt. Not a single cone or seed was found in the bush. It is said that baboons are very fond of the seeds and carry them away as soon as the cones reach their full size.

Associated with *Stangeria* in the Ngoye grass veldt is *Encephalartos brachyphyllus*, a species with small cones and tuberous, subterranean stems. I saw one tall specimen of *E. Altensteinii bispinosus*, which is called also *E. Woodii*. It is said that there is not another plant of this species within 50 miles. I did not see a single specimen of any species of *Encephalartos* in the Ngoye bush veldt.

On the grass veldt at East London, *Stangeria* is not nearly so large or so abundant as in Zululand, but its appearance is the same, the leaves projecting a little above the grass, so that most of the plants within a distance of 100 m. can be seen. In this region *Stangeria* is associated with *Encephalartos Altensteinii* and *E. villosus*, while *E. cycadifolius* grows within a few miles.

The stem of *Stangeria* is tuberous and entirely subterranean, with a strong main root and weak branches. It grows in soil so hard and stony that both care and labor must be given to secure an uninjured specimen. The stem is quite smooth, the whole leaf breaking off so cleanly that there is never any armor of leaf bases.

Nearly all the plants dug up in the East London region showed more or less branching, a feature already noted by PEARSON and by RATTRAY. Occasionally the stem is simple, but usually it bears 1–4 branches arising from the lower part of the stem, rarely from the upper part. Often the stem and branches are so nearly alike that it is difficult to distinguish which is the main stem and which is the branch. Sometimes the branching condition is betrayed by the leaves, which may be too scattered to belong to a single crown and too crowded to belong to different plants; but

it may happen that only a single branch will bear a leaf, and in that case the branching is not discovered until the soil is removed.

The stem is monoxylic, with a single very narrow zone of wood between the large pith and cortex. A stem 9cm. in diameter had a zone of xylem only 2mm. wide, and even in this zone the bundles were separated by a large amount of parenchyma. That this plant was an old one was evident, not only from its size, but also from the fact that it had borne several cones. In the field, cones are not abundant, about one coning plant in six being a liberal estimate. No observations have been made to show at what age *Stangeria* begins to bear cones, but some 5-year old seedlings in our greenhouse are only 2cm. in diameter. We did not see any cones on plants less than 5–6cm. in diameter, and we should judge that the specimen must have been at least 30 years old, perhaps much older. The display of woody tissue is the scantiest I have ever seen in any cycad of even approximately equal age.

Cone domes are numerous and are of the type already noted for *Dioon*, *Zamia*, and *Ceratozamia* (13). The main stem, therefore, is a sympodium, as are any branches which have borne more than one cone.

Sporangia

Although cones are rather infrequent, material can generally be secured in localities where the plants are abundant.

MEGASPORANGIUM.—The ovulate cone looks like that of *Dioon spinulosum*, only very much smaller, the similarity being due to the densely hairy surface and the thin rounded border of the blade portion of the sporophyll. The ovules, during earlier stages of development, are almost completely inclosed by outgrowths of the sporophyll, suggesting the angiosperm condition; but later the ovules grow rapidly and soon protrude beyond the outgrowths, which do not develop much after the ovules reach a length of 4–5mm. At maturity the ovules have a rich orange color which is quite characteristic.

Early stages in the development of the ovule have been studied by LANG (5), and its vascular anatomy has been described in detail by WORSDELL (4) and by MATTE (7).

MICROSPORANGIUM.—The staminate cones are long and slender and very symmetrical. They vary greatly in size, those growing on the dry grass veldt sometimes being as short as 8–9cm. in length, while those in the shaded bush veldt may reach a length of 20cm., exclusive of the stalk, which may be more than 5cm. in length. The sporophylls are small and the number of sporangia averages only about 150, which is lower than in any cycad except *Bowenia* and *Zamia*.

We have already stated that *Stangeria* was originally described as a fern, because the leaves so strikingly resemble those of *Lomaria*. The microsporangia are equally fernlike and bear a particularly close resemblance to those of *Angiopteris*. The wall of the microsporangium consists of an outer layer of very thick-walled cells, a very scanty tapetum, and 3–5 intervening wall layers. The thickening of the outer cells is most pronounced at the base, diminishes gradually on the sides, and at the top becomes so thin that it easily breaks, forming a pore through which the dense cell contents escape shortly before the dehiscence of the sporangium.

The earlier stages in the development of the microsporangium and in the origin and development of sporogenous tissue have been so thoroughly described and illustrated by LANG (**2**) that we have not felt it necessary to deal with this phase of the subject; but on account of the peculiar or at least newly described behavior of the chromatin at fertilization, the reduction divisions in the pollen mother cells would have been studied if material in this stage had been available.

Gametophytes

MALE GAMETOPHYTE.—The microspore is formed before any of the wall cells of the microsporangium begin to break down, but before the nucleus of the microspore divides the wall cells begin to disorganize and the tapetum becomes almost indistinguishable. During the two mitoses which result in the formation of prothallial cell, generative cell, and tube cell, the tapetum and the wall cells, with the exception of the hard outer layer, break down and form a dry, homogeneous membrane about the pollen grains, holding them together in one spherical mass. At the time of dehiscence, the

grains are dry and powdery, but are still confined by the thin membrane, which often holds them together even after they fall out from the sporangium. Most of the pollen, however, is in condition for wind pollination. Staminate cones of cycads are very frequently infested by insects, both before and after the pollen has been shed, but I have never seen anything to indicate that pollination was being affected by their agency. Besides, the ovules exude a large pollination drop, as in the case of gymnosperms known to be wind-pollinated.

When I reached Zululand, about the middle of January, 1912, the pollen tubes had already discharged; in fact, embryos were beginning to show suspensors. Although the season is somewhat later farther south, I did not find any cones in which the pollen tubes had not discharged. Accordingly, I am under great obligation to other people for material of pollen tube structures.

On January 6, 1910, Professor W. C. WORSDELL, whose extensive researches have so materially advanced our knowledge of the anatomy of cycads, visited Zululand and fixed for me some material showing pollen tubes with the sperms already formed. Mr. W. T. SAXTON, formerly of the South African College, but now of the Institute of Science at Ahmedabad, India, made several collections in the Transkei, and arranged with Miss SARAH VAN ROOYEN, of Kentani in the Transkei, for a close series of stages. The carefully prepared material furnished by Miss VAN ROOYEN yielded an excellent series of stages from the body cell, through the development of the sperm, and up to early suspensor stages in the embryo. The collections also included ripe seeds with mature embryos. Seedlings have been grown both from Professor WORSDELL'S and from Miss VAN ROOYEN'S collections.

The date of pollination was not determined definitely, but material collected in the Transkei on July 17, 1907, showed uninucleate pollen grains with exine and intine well developed. This would indicate that pollen is shed late in July. Plants from that region, now growing in our greenhouse, shed the pollen in January 1916. The sporophylls of an ovulate cone loosened at the same time, just as they do normally at the pollination period. This wide difference is due doubtless to greenhouse conditions and not

to the transfer from one hemisphere to another, for *Stangeria* in the Botanic Garden at Sydney was shedding in December 1911. The pollen at the time of shedding shows a prothallial cell, a generative cell, and a tube cell, a condition which I have now observed in all the 9 genera of the family.

Early stages in the development of the pollen tube were not observed, but later stages indicate that they do not differ essentially from the course already described in detail for *Dioon edule* (11). A characteristic view of the pollen tube structures after the pollen chamber has extended entirely through the nucellus is shown in fig. 2. In the tube at the right the body cell has divided, but in the rest the division has not yet taken place. The tube nucleus is regularly near the body cell. The haustorial end of the tube extends in a straight line a few layers of cells below the epidermis, scarcely ever showing any branching, and there are no basal haustoria like those of *Ceratozamia*. While the pollen tube structures of the cycads present many similarities, the differences are probably sufficient for a determination of the genera.

By comparing figs. 2 and 3, which are drawn to the same scale, it is evident that in the later development both the tubes and the sperms increase greatly in size. It is during this rapid increase in size that the spiral band with its immense number of cilia develops from the blepharoplast. The cycad sperm is the largest and most complicated motile cell in either plants or animals. While the series of stages in *Stangeria* is quite satisfactory, the series in *Ceratozamia* is even more complete, thanks to Mr. ALEXANDER M. GAW, of Jalapa, Mexico, who for 10 years has been sending material to supplement my own collections. Besides, the blepharoplast of *Ceratozamia* is larger. Consequently, a more detailed study of the development of the sperm will be reserved for this genus; but some of the more obvious features, as they appear in *Stangeria*, will be presented here.

While the body cell remains elongated during the early stages in the development of the tube, the two blepharoplasts occupy the fore and aft positions; but as the basal end of the tube enlarges and the body cell becomes spherical, the blepharoplasts rotate 90°, so that their axis becomes transverse to the long axis of the tube.

At first, the blepharoplast is a solid, homogeneous body, but as it increases in diameter it becomes vacuolate and soon appears to be little more than a shell containing droplets of liquid (fig. 4). This stage is reached before the body cell divides. During the division of the body cell, the vacuolate blepharoplast breaks up into hundreds of small granules which, for a short time, occupy the space previously occupied by the blepharoplast (fig. 5). The daughter nuclei immediately after the division of the body cell are smaller than the blepharoplasts; but the nuclei increase rapidly in size, while the group of granules remains stationary until it begins to form the ciliated band. The beginning of the band takes place during a rapid increase in the size of the sperm (fig. 6). Many of the granules become elongated and have a distinct tendency to arrange themselves in rows, forming a band one layer of granules in thickness (fig. 7). From the entire surface of one side of this band, stiff bristle-like cilia grow out. The young band is variously twisted and curved, so that the bristles point in every direction, some of them even toward the nucleus, but the band soon turns so that all the bristles face outward (fig. 8). As the band nears the surface, the bristles prick through the cytoplasm and the growth of the cytoplasm at this point is checked, so that a spiral groove results. After piercing the cytoplasm, the bristles grow out into long, slender cilia, which at first are compressed by the wall of the sperm mother cell, but later extend outward and vibrate vigorously when this wall breaks down. The mature sperm varies from 150 to 190 μ in diameter, and its dense nucleus constitutes most of its mass, the diameter of the nucleus being usually only about 20 μ less than that of the entire sperm, so that the cytoplasm containing the spiral band is only a thin sheath. The number of turns in the spiral varies from 5 to 7, but one peculiar sperm was found with a long, narrow apex and 10 turns of the band (fig. 10).

Female gametophyte.—In the young nucellus Lang (**5**) found an axial row of 3 cells, the lowest of which became the functioning megaspore. In my own material the earliest stages showed archegonia shortly before the division which gives rise to the ventral canal nucleus and the egg. The figure for this division was observed only once, but it was not difficult to determine the

number of chromosomes as 12. Several preparations show that no wall is formed between the two nuclei, and that the ventral canal nucleus soon disorganizes, while the egg nucleus increases rapidly in size as it moves toward the center of the egg.

Some irregularities were noted. In two cases there were 4 neck cells instead of 2, in one of the two cases the two original cells having divided longitudinally, and in the other transversely. In several cases the central cell of the archegonium had not continued its development and was no larger than the tissue cells of the gametophyte, but the two neck cells were as large and turgid as those of a normal archegonium.

Fertilization

The archegonial chamber at the time of fertilization is moist, but no droplets of fluid can be seen, even with a 16 mm. objective. On the other hand, the pollen tubes are turgid, and as they discharge furnish enough fluid for a limited movement of the sperms. After the nucellus has been removed from the ovule, it is easy to see the sperms swimming in the pollen tube, but practically impossible to observe them, under natural conditions, in the archegonial chamber. The entrance of the sperm into the egg is probably effected as already suggested for *Dioon edule* (**12**). The liquid discharged from the pollen tube is of high osmotic pressure, and consequently draws some liquid from the turgid neck cells, and the lowered turgidity of these cells allows a portion of the upper part of the egg to escape, thus forming a vacuole which draws the sperm into the egg. The careful experiments of MIYAKE (**8**) have shown that the cycad sperm does not respond to chemotactic stimuli, being indifferent even to the material of the egg.

It is quite common for more than one sperm to pass through the neck of the archegonium, but rare for more than one to enter the egg itself (figs. 10, 11, 13). In one case 7 extra sperms had passed through the neck; in another case 4; in several cases 3; and in many cases 2 or 1. The apex of the extra sperm is usually directed toward the main body of the egg, and in such cases the sperm becomes more or less imbedded, doubtless on account of the movements of the cilia; but when the axis is not directed in this way,

the sperm is not likely to cause so deep a depression (figs. 10, 11, 13). The ciliated band is so conspicuous and persists so long that a complete series of sections will show, even to the close of the free nuclear period, whether more than one sperm has entered the egg. The photomicrograph (fig. 24) shows a part of the spiral band of the sperm whose nucleus has fused with that of the egg; and also shows two more sperms which have passed through the neck, one of which has become almost completely imbedded in the egg.

The behavior of the chromatin during fertilization has not yet been described for any cycad, but WEBBER (**6**) figured and described the sperm nucleus of *Zamia* imbedded in the egg nucleus, and IKENO (**3**) found the same condition in *Cycas*. In *Stangeria* the behavior is the same (fig. 9). Both nuclei, at this stage, are in the resting condition. Whether they continue in this condition as fusion proceeds, or break up into two groups of chromosomes, as in *Pinus* and several other conifers, has not been observed as yet. However, the structure of the first mitosis of the fertilized egg indicates that the resting condition is soon followed by the formation of chromosomes by each of the fusing nuclei. The number of chromosomes, as counted at the equatorial plate stage of the first mitosis, is 12; but later free nuclear divisions and also mitoses in root tips show that 24 is the diploid number; further, the mitosis at the formation of the ventral canal nucleus and egg shows 12 chromosomes, proving that this is the haploid number. With the conspicuous spiral band indicating the entrance of a sperm, parthenogenesis is out of the question. HUTCHINSON'S (**14**) recent study of fertilization in *Abies*, from an abundance of material in critical stages, which it has been my privilege to examine, furnishes an explanation of this apparently haploid, but really diploid condition. HUTCHINSON (**14**) finds that the spirems of the two conjugating nuclei segment into chromosomes, as has been described for various conifers; but, after the segmentation, the chromosomes unite in pairs, just as in the prophase of the heterotypic mitosis. Each pair then segments transversely and the two longitudinal parts separate, so that 4 chromosomes are formed from each pair and the diploid number is established. In *Stangeria*, 4 eggs were found which showed the first mitosis, all of them in the early

equatorial plate stage. In all of these the number of chromosomes is 12, but the double character of the chromosomes is evident; and since 12 and 24 are the haploid and diploid numbers, I believe that there is a pairing of chromosomes at fertilization, as described by HUTCHINSON (**14**) for *Abies*.

Embryogeny

FIRST MITOSIS.—At the first division in the fertilized egg, the mitotic figure is surrounded by a remarkable display of achromatic structures, arranged in irregular nets or grouped into cones resembling half-spindles (figs. 10, 11, 25). This achromatic area easily identifies the first mitosis, even when a second sperm has entered and divided, since the achromatic area surrounding the dividing sperm is much smaller (fig. 11). The division of an extra sperm was observed in two cases, and in both the mitotic figure showed 12 chromosomes. After the first mitosis the achromatic display gradually diminishes, but is still quite conspicuous as late as the fourth or fifth division. After the first mitosis, however, the display consists almost entirely of slender threads like the spindle fibers (fig. 26).

FIRST FREE NUCLEAR PERIOD.—According to previous accounts of the embryogeny of cycads and *Ginkgo*, there is a regular series of free nuclear divisions, so that the nuclei at the successive divisions number 2, 4, 8, 16, 32, 64, 128, 256, 512, and in some cases 1024, with only such variations as might be expected from the occasional failure of a nucleus to divide. In *Dioon edule* (**12**) it was noted that the 8th, 9th, and 10th mitoses were irregular, especially in the upper part of the proembryo, so that the number of nuclei beyond the 256-nucleate stage was likely to vary widely from the theoretical estimate.

In *Stangeria*, irregularities begin to appear earlier and are more pronounced. The first 4 mitoses, giving rise to 2, 4, 8, and 16 nuclei, are likely to be strictly simultaneous and regular, and the 32-nucleate stage was observed in two cases; but after the 16-nucleate stage (fig. 12), the number of nuclei not only varies from the anticipated 32, 64, 128, etc., but the discrepancies are great. An examination of a large number of cases showed that the

free nuclei in the upper half of the proembryo were often smaller and more numerous than those in the lower half. The explanation was soon found, for the nuclei in the upper half may divide simultaneously, while those in the lower half remain in the resting condition (fig. 14). This would double the number of nuclei in the upper part, and naturally the nuclei would be smaller. A counting of nuclei in several complete series of sections indicated that such a division had taken place. When the lower nuclei divide, the upper ones divide also, even if they are already much more numerous (fig. 13). There is one important exception to this statement which will be considered later.

While such nuclear conditions are frequent, they are not universal, for two series showed approximately 512 nuclei of uniform size and uniformly distributed throughout the egg, thus indicating that there had been 9 simultaneous divisions. With the 9th or sometimes the 10th nuclear division the free nuclear period comes to a close.

At any time after the 7th division there may be an evanescent segmentation of the protoplasm, especially in the upper part of the proembryo (fig. 15). We have already described such a condition in *Dioon edule* (**12**), and while we have not yet published the details, we may state that in *Macrozamia*, *Encephalartos*, and *Cycas* the segmentation is much more complete than in *Stangeria* or *Dioon*, and is more permanent, since cellulose walls are formed.

As already stated, the haploid and diploid numbers of chromosomes are 12 and 24. The number 24 is fairly stable in the lower part of the proembryo; but in the upper part there are frequent and extreme variations, the numbers ranging from the theoretical 24 down to a single chromosome. If many of the figures should show just 12 chromosomes, the number could be explained by the continued division of an extra sperm, the first division of which has already been noted; but no such cases were observed. The cause of the irregularity was not determined.

Polarity.—A striking feature of the free nuclear period is the frequency of a definite polarity. During the earlier divisions, the nuclei may be fairly evenly distributed, but still in two recognizable groups (fig. 12). Very often, however, the grouping is conspicuous, with a considerable space separating the upper and lower

groups (fig. 13). Sometimes the middle third of the proembryo is entirely free from nuclei; sometimes the nuclei are distributed throughout, but are smaller and more numerous above; sometimes the nuclei are dividing above but resting below, and later they divide below while the nuclei above are resting; there may be evanescent segmentation above, but no trace of it below; later, there is a migration of nuclei toward the base, followed by segmentation below, with none above; the embryo is formed below, while the upper region furnishes nutrition. In fact, there is a constant manifestation of polarity from the appearance of the archegonium initial throughout the life of the plant. The source of nutrition is probably the cause of a part of these phenomena, but much is still to be explained.

CAUSE OF FREE NUCLEAR PERIOD.—Why the cycad embryogeny should begin with a period of free nuclear division is not hard to imagine. It would seem a physical impossibility for the small mitotic figure of the first division to segment the comparatively immense mass of the egg. Further, the large amount of nutritive material doubtless causes the nuclear divisions to follow in rapid succession. That they do follow in rapid succession is shown by the fact that the 2-, 4-, and 8-nucleate stages are very rarely found; and also by the fact that nuclei which have reached the resting condition are not likely to be found before the 16-nucleate stage. Further, a glance at the illustrations accompanying this paper will show that the mitotic figures, nearly 100, are all in the equatorial plate stage, a fact which indicates that other phases are comparatively rapid.

The small size of the mitotic figure, the great mass of the egg, and the rapid succession of mitoses doubtless cause the free nuclear period which characterizes not only cycads, but nearly all living gymnosperms. As the divisions proceed and the mass of the nucleus approaches that of the surrounding cytoplasm, segmentation, which may be more or less evanescent, appears; and later permanent segmentation with the formation of cellulose walls takes place. In the Bennettitales and earlier cycadophytes the seeds were much smaller than in any of the living cycads yet studied. It would be interesting to know the embryogeny of these forms.

An examination of the tiny *Zamia pygmaea* might show a comparatively short free nuclear period, but I have not yet been able to secure it. *Ginkgo*, with its comparatively small eggs, has only 7 free nuclear divisions, the walls appearing with the 8th division. *Selaginella* and *Isoetes* have a short period of free nuclear division at the germination of the megaspore, but none of the living heterosporous pteridophytes has any free nuclear division in the embryogeny. These stages have not yet been described in any fossil heterosporous pteridophyte, but some of the paleozoic forms had megaspores much larger than those of *Isoetes* or *Selaginella*. Doubtless, with the increase in the size of the egg, a free nuclear period became established, becoming more and more extensive as the egg became larger, until it reached its maximum in some of the living cycads, which have eggs 5 or 6mm. in length, and which may have more than 1000 free nuclei before wall formation begins. Among the coniferophytes, *Ginkgo* has the most extended free nuclear period yet known. While we believe that the *Ginkgo* condition represents a culmination, it is not so clear that genera with less and less extended free nuclear periods in the embryogeny represent a reduction series, ending in forms like *Sequoia*, in which a cell wall follows the first mitosis in the fertilized egg. This may seem rather speculative, but we believe enough has been observed to warrant our theory that the origin and development of the free nuclear period has been due to a progressive increase in the size of the egg.

MIGRATION OF NUCLEI.—As soon as the first free nuclear period has come to a close, many of the nuclei in the upper and middle portions of the proembryo migrate to the bottom (figs. 16, 17, 18, 27). That nuclei actually move to the basal region is shown by the structure of the cytoplasm and arrangement of the nuclei, and also by the relative numbers of nuclei in the upper and lower parts of the proembryo. The cytoplasm becomes vacuolated in the lower portion, before any movement of the nuclei begins (fig. 15); but during the movement and in succeeding stages the vacuolated condition extends throughout. As the nuclei move to the base of the proembryo, the cytoplasm at that point becomes denser and denser, until it contrasts rather sharply with the vacuolated structure above (fig. 18).

SECOND FREE NUCLEAR PERIOD.—After the migration of nuclei, there is a second period of simultaneous free nuclear division at the base of the proembryo, but the nuclei above do not divide (fig. 19). The mitotic figures of this division were observed in only two cases, but in two others there was evidence that such a division had recently occurred. Since so few cases were observed, the extent of this free nuclear period could not be determined, but early stages in the cellular period would indicate that there are probably only two or three simultaneous mitoses before wall formation begins. The cause of this second period is probably the dense basal accumulation of cytoplasm during the migration of nuclei. The embryo, the suspensor, and some cells which remain within the limits of the egg are all formed from cells resulting from the second free nuclear period, the nuclei and cytoplasm above being resorbed by the growing embryo.

IKENO (3), in his classic account of *Cycas revoluta*, described free nuclear mitoses at the base of the proembryo, with amitotic divisions above, but did not give any further description of the embryogeny. His investigation dealt chiefly with the pollen tube structures and oogenesis. TREUB (1), who had previously made a study of *Cycas circinalis*, did not mention such a stage.

FORMATION OF WALLS.—At the close of the second free nuclear period, with the last simultaneous mitosis, there is a simultaneous formation of cell walls (fig. 20). At the middle of the cellular region there are about three layers of cells with cellulose walls, and at the edges only one layer. Above these cells with cellulose walls there is a segmentation of the cytoplasm, but the walls do not reach the cellulose stage and are weak and evanescent. Within the cellular region, mitoses are no longer simultaneous, and each nuclear division is followed by the formation of a wall. The region soon becomes sharply marked off from the cytoplasm above (fig. 21). Later, the peripheral walls of the cells bordering upon the cytoplasm become thickened, so that the cellular region is still more sharply defined (fig. 23). The thickening is mucilaginous. The free nuclei in the cytoplasm may undergo occasional divisions, giving rise to numerous small nuclei (fig. 21), while the cytoplasm bordering upon the cellular region becomes denser, losing more or

less completely its vacuolated appearance as it is resorbed by the rapidly developing embryo. Before the appearance of cotyledons, the young embryo has resorbed all the cytoplasm and nuclei of the free nuclear region, which becomes an empty shell, maintaining its contour only by the rigidity of the tough egg membrane. All the structures of this region, however, are finally crushed by the backward thrust of the suspensor, which is stopped only by the stony coat of the seed.

DIFFERENTIATION OF CELLULAR REGION.—Differentiation of the cellular region begins almost as soon as it is marked off from the free nuclear region above it. At first there is seen a differentiation into two general regions: the upper, in contact with the free nuclear region, consisting of larger cells; while the cells of the lower are much smaller, but denser and more numerous (fig. 21). Some of the upper cells, especially in the center, increase greatly in size and become actively haustorial; it is through these that the contents of the free nuclear region pass down to the developing embryo (fig. 23).

The smaller, denser cells then become differentiated into two regions, the lower consisting of a single layer of large cells which looks like a dermatogen, and above it several layers of small, dense cells (fig. 22). Most of the outer cells become haustorial, especially at the center. These cells partly digest and partly crush the egg membrane, and the young embryo begins to advance into the endosperm (fig. 23). Only a small portion of the egg membrane is ruptured, and the advancing embryo is extremely narrow in comparison with those of cycads previously described. The region of small, dense cells contributes most of the suspensor and all of the periblem and plerome of the embryo.

Stages in the development of the body regions of the embryo are still lacking in my material, but will doubtless be found in collections now being made in South Africa. From the mature embryo up to seedlings with several leaves the series is fairly complete, and some account will be given at another time in connection with a study of seedlings of other genera.

This paper, like several earlier papers on cycads, is largely descriptive. Since material is in hand for a fairly complete study

of all the genera, it seems wiser to reserve theoretical considerations until the available evidence has been examined.

Summary

1. *Stangeria* is probably monotypic, with *S. paradoxa* as its single polymorphic species.

2. At fertilization there is a pairing of chromosomes resembling the pairing in the heterotypic mitosis, so that the number during the metaphase of the first division is apparently haploid, although really diploid.

3. There are two free nuclear periods in the embryogeny, the first comprising 9 or 10 simultaneous mitoses and extending throughout the proembryo, and the second with only 2 or 3 mitoses and confined to the lower part of the proembryo. The embryo and suspensor are formed from the second series.

4. There is an evanescent segmentation of the entire egg, as in *Dioon*.

5. The young embryo is very narrow and its haustorial structures are more conspicuous than in any other cycad yet described.

6. Polarity, which may appear even at the beginning of embryogeny, becomes more and more marked as development proceeds.

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EXPLANATION OF PLATES XXIV–XXVI

Most of the sections were cut at 5 μ; none was thicker than 10 μ. With the exception of figs. 4–8, the drawings were reconstructed from two or more sections. Figs. 12 and 13 are reconstructed to show all the nuclei of these proembryos.

FIG. 1.—Text cut, showing *Stangeria* in the field.

FIG. 2.—Nucellus with pollen tubes showing prothallial cell, stalk cell, body cell with blepharoplasts, and tube nucleus; in one tube (at the right) the body cell has divided; ×50.

FIG. 3.—Later stage: mature sperms are about to be shed; ×50.

FIG. 4.—Blepharoplast, much vacuolated, shortly before breaking up into granules; the body cell has not yet divided; ×365.

FIG. 5.—The blepharoplast has broken up into an immense number of small granules; the nucleus of the young sperm is smaller than the blepharoplast of the preceding figure; the median portion of the spindle can still be seen; ×365.

FIG. 6.—The granules have increased in size and number and are becoming arranged into a flat band; note the great increase in the size of the nucleus; ×365.

FIG. 7.—Transverse section of a band at the stage shown in fig. 6; ×365.

FIG. 8.—The bristle-like cilia beginning to develop from the band; some are directed toward the nucleus; ×365.

FIG. 9.—Fertilization: the sperm nucleus entering the egg nucleus; the ciliated band remains at the top of the egg; ×42.

FIG. 10.—First mitosis in the fertilized egg: at the top, 3 sperms which have passed through the neck, but have not entered the egg; the ciliated band of the sperm which effected fertilization is easily seen; ×42.

FIG. 11.—First division of fertilized egg: a second sperm has entered and is dividing in the upper part of the egg; two more sperms which have almost entered the egg are seen at the top; ×42.

FIG. 12.—The fourth simultaneous free nuclear division; ×42.

FIG. 13.—At the bottom, 8 approximately equal nuclei are dividing; at the top, the division is also simultaneous, but the number of nuclei is large and they are irregular in size; there is a very marked polarity; ×42.

FIG. 14.—The nuclei of the lower half are large and are in the resting condition, while those of the upper half are smaller and are dividing simultaneously; the polarity is evident; ×42.

FIG. 15.—Evanescent segmentation: the nuclei of the lower part are larger and the cytoplasm is becoming vacuolated; ×42.

FIG. 16.—Many nuclei have migrated to the bottom and the cytoplasm of the entire proembryo is vacuolated; the ciliated band is still evident at the top; ×42.

FIG. 17.—Slightly later stage: many nuclei have amoeboid shapes; ×42.

FIG. 18.—Nuclei with dense cytoplasm at the base of the proembryo, just before the second free nuclear period; ×140.

FIG. 19.—Free nuclear division of the second free nuclear period; ×140.

FIG. 20.—Segmentation at the close of the second free nuclear period; ×140.

FIG. 21.—The cellular region is differentiated from the free nuclear region and there is some differentiation within the cellular region itself; ×100.

FIG. 22.—An outer layer of dermatogen-like cells has been differentiated; the dense cells just above are to produce the periblem, the plerome, and most of the suspensor; ×100.

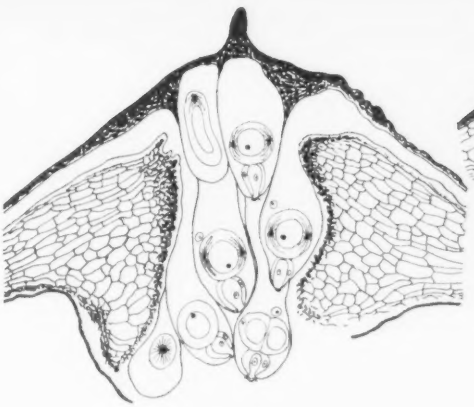
FIG. 23.—The upper cells of the cellular region are distinctly haustorial, and the slender tip, which has just broken through the egg membrane, is composed largely of haustorial cells; ×100.

FIG. 24.—Photomicrograph: upper part of fertilized egg, showing a part of the ciliated band and two sperms which have almost entered the egg; ×80.

FIG. 25.—Photomicrograph: first mitosis in fertilized egg, showing the mototic figure and the conspicuous kinoplasmic area about it; ×86.

FIG. 26.—Photomicrograph: one of the mototic figures of the fourth simultaneous free nuclear division; ×517.

FIG. 27.—Proembryo, showing the migration of nuclei toward the bottom; ×33.



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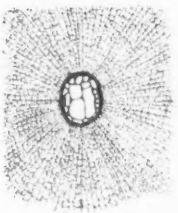

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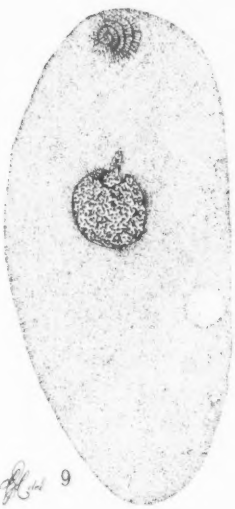

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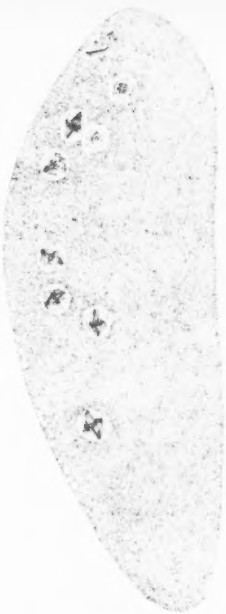

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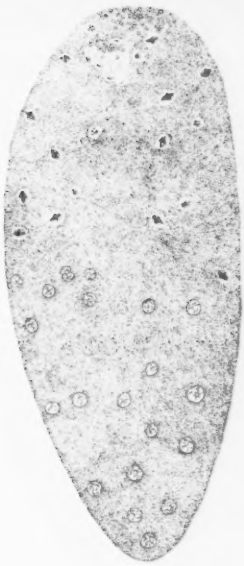

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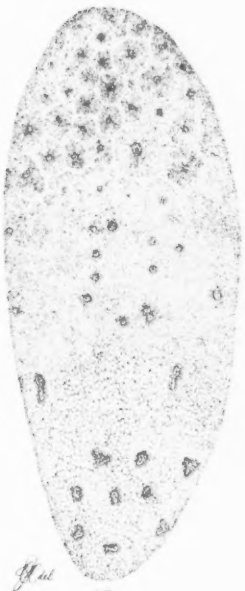

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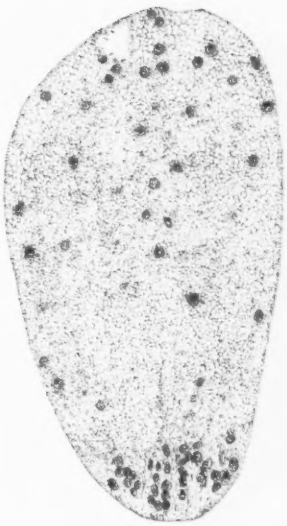

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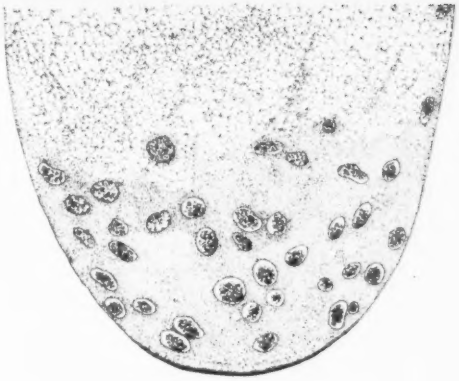
CHAMBERLAIN on STANGERIA



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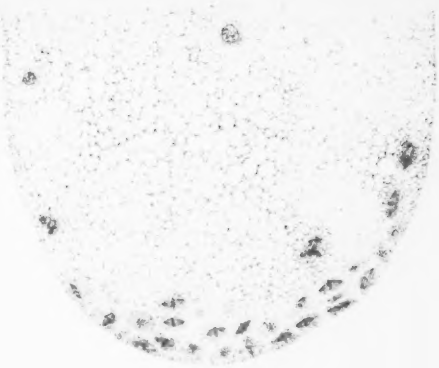

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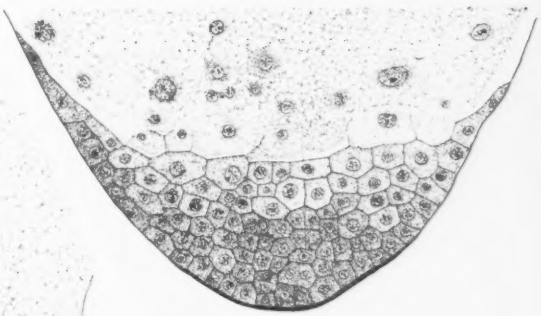

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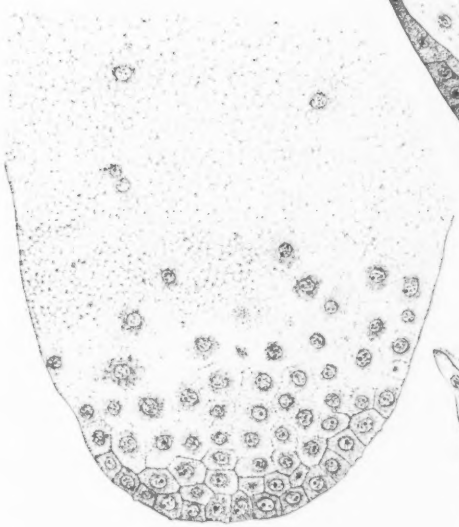

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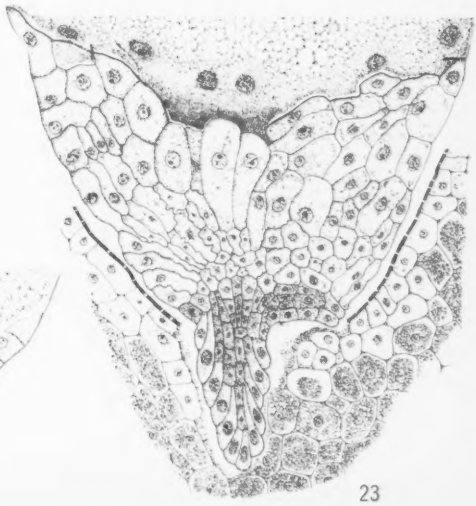

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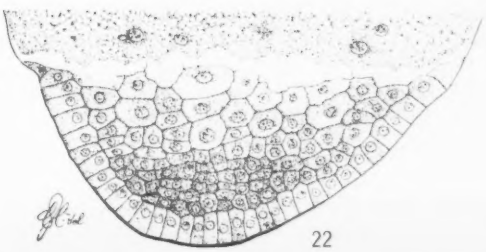

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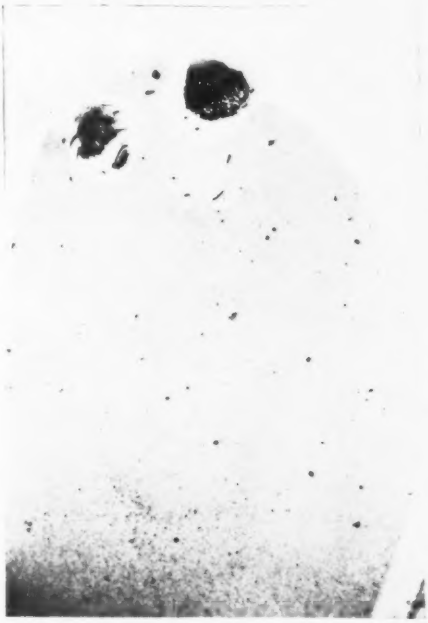
CHAMBERLAIN on STANGERIA



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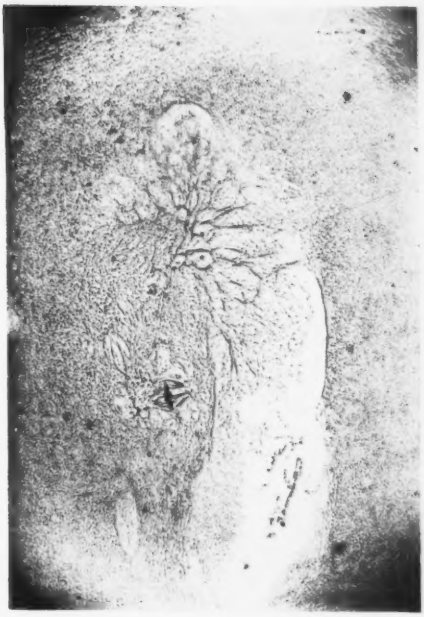

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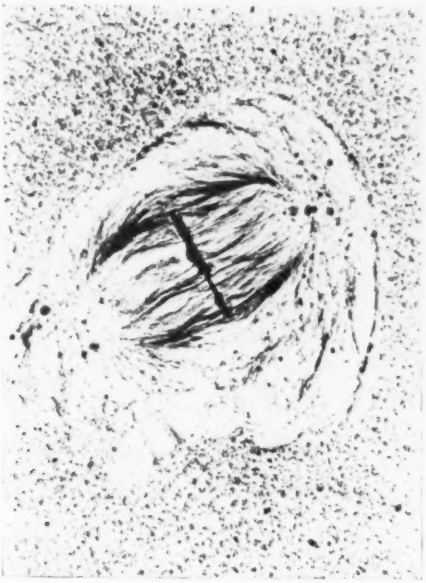

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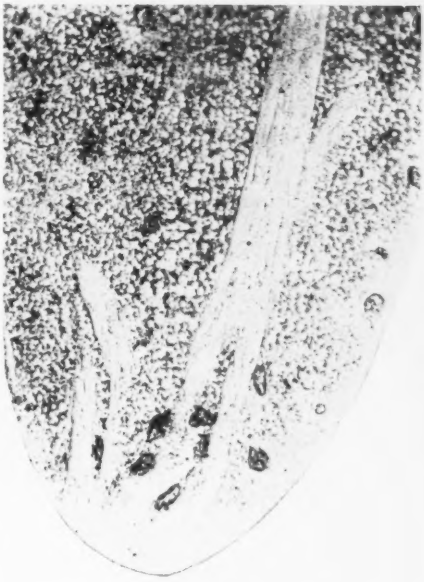

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CHAMBERLAIN on STANGERIA

UNDESCRIBED PLANTS FROM GUATEMALA AND OTHER CENTRAL AMERICAN REPUBLICS XXXIX[1]

JOHN DONNELL SMITH

Celastrus vulcanicolus Donn. Sm.—Folia coriacea nitida oblongo-elliptica apice acuminata basi cuneata subintegra. Racemi singuli simplices laxiflori, pedicellis medio articulatis ibidem ebracteolatis basi deltoideo-bracteatis, floribus minimis. Petala oblonga obtusa genitalibus longiora. Stamina sub disco inserta, antheris cordatis. Ovarium triloculare, loculis uniovulatis. Capsula late ellipsoidea monosperma.

Frutex omnibus in partibus glaberrimus, ramulis lenticelligeris, novellis racemisque angulatis purpureo-fuscescentibus. Folia 6–8 cm. longa 2–3 cm. lata calloso-apiculata supra medium subobsolete calloso-appressoque-serrulata, costa supra subimmersa subtus robusta prominente, nervis lateralibus utrinque 6 nonnisi subtus conspicuis, petiolis 3–4 mm. longis canaliculatis, stipulis ciliiformibus aegre perspiciendis deciduis. Racemi 8–12-flori, floriferi 1.5–2 cm. longi, fructiferi 3.5–4.5 cm. longi, pedicellis 4 mm. longis, bractea 0.5 mm. longa. Calyx basi cupularis incrassatus, segmentis jam in alabastro ovoideo 2 mm. longo liberis ovatis obtusis 0.75 mm. longis. Petala imbricata 1.3 mm. longa. Stamina 1 mm. longa. Discus prominens pentagonus 2 mm.-diametralis. Ovarium liberum depresso-globosum 1 mm. altum, ovulis erectis, stylo vix ullo, stigmatibus 3. Capsula nondum satis matura clausa calyce persistente fulta tenuiter coriacea 1.6–2 cm. longa basi contracta unilocularis, valvis loculicide cohaerentibus intus medio septicide late alatis, semine nonnisi juvenili viso capsulam inflatam parum implente, arillo purpurascente.—Ad *C. racemosam* (Reiss.) Loes. et ad *C. Pringlei* Rose proxime accedens.

In declivibus ad Volcán de Fuego, Depart. Zacatepéquez, Guatemala, alt. 1900 m., Mart. 1892, *John Donnell Smith*, n. 2549 ex Pl. Guat. etc. quas edidit Donn. Sm.

Gilibertia diplostemona Donn. Sm.—Folia simplicia integra coriacea elliptica tenuiter acuminata in petiolum angustata. Stipulae obsoletae. Umbella terminalis solitaria pedunculata pluriradiata ter quaterve irregulariter decomposita densiflora

[1] Continued from BOT. GAZ. 57:427. 1914.

pubescens. Calycis margo subinteger. Petala 4–5 calyptratim decidua. Stamina 8–10. Styli 2–3 in columnam connati.

Frutex scandens absque umbella glaberrimus, ramulis sulcatis striatis rufescentibus linea elevata interpetiolari circumdatis defolatione insigniter cicatrisatis, internodiis superioribus 4–4.5 cm. longis. Folia 14–17 cm. longa 5.5–8 cm. lata, costa sicut nervi laterales utrinque 7–8 subtus robusta, areolis minutis, petiolis 15–17 mm. longis basi incrassatis, cicatricibus obovatis 4 mm. longis foveolato-punctatis. Pedunculus 2.5 cm. longus 4 mm. crassus sulcatus striatus rufescens medio et supra medium linea elevata circumdatus apice sub insertione radiorum in pulvinum dilatatus, umbella tota cum floribus rubicunda (cl. *Pittier* in schedula), semiglobosa 4 cm. alta 6 cm. lata, radiis primariis 12–13 circiter 1.5–2.5 cm. longis, umbellulis pancius et inaequaliter radiatis, pedicellis 1–3 mm. longis ebracteolatis, floribus cum pedicello continuis congestis. Calyx obpyramidalis 1 mm. longus atque latus margine undulatus. Petala valvata oblongo-ovata 2.5 mm. longa acuta apice cohaerentia. Stamina per paria petalis opposita, filamentis in alabastro inflexis per anthesin erectis, antheris filamenta subaequantibus ellipticis 1.25 mm. longis bis longioribus quam latioribus basi affixis didymis viridulis. Discus in columnam stylorum 0.75 mm. longam abiens. Fructus deficit.—Secundum clavem specierum Centrali-Americanarum in Bot. Gaz. **55**:436. 1913 ad inflorescentiam adumbratam haec juxta *G. querciti* Donn. Sm. inserari debetur, differt tamen umbella decomposita.

In silvis ad fundum *Tuis* dictum, Prov. Cartago, Costa Rica, alt. 700 m., Dec. 1900, *H. Pittier* (sine numero).

Isertia Deamii Bartlett, var. **stenophylla** Donn. Sm.—Folia lanceolata 4-plo et ultra longiora quam latiora deorsum longe attenuata pernumerose nervata. Thyrsus foliis fulcientibus aequilongus lanceolato-ovoideus. Calyx denticulatus. Corolla flava.

Folia 28–35 cm. longa medio 6.5–8.5 cm. lata, nervis lateralibus utrinque circa 25–26. Thyrsus pedunculo aequilongo adjecto 26 cm. longus, rhachi 9 cm. longa, cincinnis inferioribus usque ad 4 cm. longis tortuosis 6-floris, floribus flavis (ex cl. *Pittier*). Calycis denticuli breves lati acuti.

In planetiebus prope Boca Culebra, Comarca de Puntarenas, Costa Rica, alt. 50 m., Jan. 1898, *H. Pittier*, n. 11989.

Hoffmannia nesiota Donn. Sm.—Folia generis inter maxima elliptica acuminata in petiolum subtriplo breviorem longe attenuata coriacea glabra. Pedunculi 2–4-ni petiolo subduplo superati, cymis corymbiformibus laxifloris, pedicellis gracilibus. Calycis tubus pyramidalis acute trigonus dentibus 4-triangularibus dimidio

longior. Corolla triente fida. Ovarium triloculare. Bacca maxima globosa.

Frutex in dumetis confertim crescens (ex cl. *Pittier*), ramulis subteretibus fistulosis lenticellatis glabris linea interpetiolari elevata notatis, stipulis ignotis. Folia 22–26 cm. longa medio 10.5–11 cm. lata in petiolum 7.5–8 cm. longum decurrentia, costa cum nervis lateralibus utrinque 14–16 supra subimpressa subtus prominente, areolis crassis. Cymae unilaterales (sicut inflorescentiam praebent monochasialem omnes congenerae ut videtur), pedunculo 3.5–5 cm. longo lenticellato glabro adjecto 5–8 cm. longae 5–10-florae cum floribus pube patente fusca sparsim pilosiusculae, bracteis bracteolisque obsoletis, pedicellis 6–10 mm. longis, floribus 15–16 mm. longis. Calyx 5 mm. longus eglandulosus. Corolla 11 mm. longa fuscescens, segmentis 4 linearibus levissime imbricatis. Stamina 4 faucibus corollae inserta, antheris subsessilibus linearibus 5.5 mm. longis conectivo fusco producto apiculatis. Discus elevatus pulvinaris. Ovarium anthesi peracta oblongo-obovoideum bis longius quam latius subtetragonum, stylo 12 mm. longo, stigmatis lobis subconnatis oblongo-ovatis 1.5 mm. longis. Bacca 1 cm.-diametralis dentibus calycinis haud accrescentibus coronata trilocularis 4-costata, seminibus ellipsoideis 0.5 mm. longis foveolatis rubellis.—Ad. *H. Pittieri* Standley foliis accedens ab ea inflorescentia recedit.

In humidis ad *Wafer Bay*, Insula Cocos in mari Pacifico, Costa Rica, Jun. 1898, *H. Pittier*, n. 12387.

Rudgea (§ NOTACANTHAE K. Sch.) **thyrsiflora** Donn. Sm.—Folia glabra lanceolato-elliptica sursum tenuiter deorsum brevius acuminata, stipulis in vaginam utrinque bisetosam inter setas aculeoligeram connatis. Thyrsus foliis 3–4-plo brevior anguste conicus densiflorus ferrugineo-pubescens, floribus cymulosim confertis subsessilibus. Calycis lobi tubum subaequantes. Corolla tubus urceolatus lobos calycinos bis superans segmenta propria filiforme corniculata aequans.

Rami teretes ferrugineo-pubescentes. Folia membranacea 19–23 cm. longa 6–8 cm. lata, costa cum nervis lateralibus utrinque circiter 13 subtus prominente et fusco-puberula, venis transversis crebris, petiolis 8–15 mm. longis, stipularum ferrugineo-pubescentium vagina 5 mm. longa margine aculeis cartilagineis 1 mm. longis munita, setis 10–13 mm. longis rigidis. Thyrsus pedunculo 1.5 cm. longo adjecto 5.5 cm. longus basi 1.5 cm. latus, ramis alternis approximatis, inferioribus 3 mm. longis, superioribus vix ullis, cymulis trichotomis aggregatis, bracteis linearibus 6–10 mm. longis basi saepe subulato-bidentatis, bracteolis linearibus florem paene aequantibus, floribus 4–5-meris. Calyx 2 mm. longus, lobis ovatis. Corolla cum calyce extus sparsim ferrugineo-strigillosa, tubo 2 mm. longo, segmentis prope basin

cucullatis et cornu 2 mm. longo appendiculatis. Antherae tubi medio barbato insertae inclusae. Discus pulvinatus ovarium aequans. Stylus corolla fauces attingens, ramis linearibus. Fructus ignotus.

In silvis ad Tsâki, Talamanca, Comarca de Limón, Costa Rica, alt. 200 m., m. Apr. 1895, *Ad. Tonduz*, n. 9579.

Cephaelis (§ PLEIOCEPHALEAE Muell. Arg.) **tetragona** Donn. Sm.—Folia oblongo- vel obovato-lanceolata stipulis utrinque binis triangularibus basi connatis. Capitula in paniculam corymbiformem sessilem bis trichotomam disposita inconspicue pedunculata multiflora, bracteis scariosis, exterioribus orbicularibus calycem aequantibus, interioribus brevioribus ovato-lanceolatis, intimis rudimentariis vel obsoletis, floribus bracteas bis et ultra superantibus. Drupa maxima tetragona, pyrenis dorso acutis facie ventrali sulcatis.

Arbusculus praeter paniculae axes sordide pubescentes bractearum apicem ciliolatum corollae fauces barbatas omnibus in partibus glaber, ramis teretibus, internodiis 2–4 cm. longis, stipulis 4 mm. longis, foliis pergameneis 11–21 cm. longis 4–5 cm. latis apice saepius contracto-acuminatis basi acutis vel acuminatis, nervis lateralibus utrinque 12–14, petiolis 5–7 mm. longis. Paniculae floribus ademptis 4–6 cm. longae rami primarii 1.5–2.5 cm. longi secundarii 3–5 mm. longae bracteis foliaceis 10–14 mm. longis fulti, capitulis 6–12-floris, bracteis discretis basi dilatatis concavis nervosis, exterioribus 9–10 mm. longis, floribus 5-meris. Calyx sessilis turbinatus 9–10 mm. longus, lobis rotundatis 1.5 mm. longis. Corolla tenuiter tubulosa 25–28 mm. longa luteola exannulata, lobis 10 mm. longis, ore staminigero. Antherae exsertae lineares 5 mm. longae infra medium affixae. Discus annularis crenulatatus. Stylus inclusus. Drupa nigra ellipsoidea 11–13 mm. longa 8–9 mm. lata calyce coronata tenuiter carnosa acute tetragona angulis septalibus bicostata, pyrenis osseis, semine 10 mm. longo 7 mm. lato 3 mm. crasso.

In silvis ad Tuís, Prov. Cartago, Costa Rica, alt. 650 m., Oct. 1897, *Ad. Tonduz*, n. 11352.—In silvis apud *Las Vueltas*, Tucurrique, Prov. Cartago, Costa Rica, alt. 600–700 m., Feb. 1899, *Ad. Tonduz*, n. 12997.

Zexmenia thysanocarpa Donn. Sm.—Folia minima ovata. Involucrum hemisphaericum, bracteis 3-seriatis membranaceis mucrone herbaceo apiculatis, exterioribus orbiculari-ovalibus, interioribus longioribus ellipticis. Receptaculum conicum, paleis in aristam nigram contractis. Achenia radii exalata 3-aristata, disci niveo-pectinatoque-alata, alis sursum auriculato-productis, aristis nullis squamellis obsoletis.

Fruticulus decumbens e basi ramosus, ramulis cano-pubescentibus ad apicem versus cano-villosis. Folia 10–12 mm. longa 7–8 mm. lata obtusa

basi rotundata vel subcordata subintegra utrinque pilis bulbosis canis adspersa, nervis lateralibus praeter basales subobsoletis, petiolis 2–3 mm. longis. Capitula terminalia solitaria sessilia foliis 4 fulta, foliis interioribus reductis 5–6 mm. longis. Involucri bracteae circiter 18 concavae nervatae, exteriores 4 mm. longae, interiores 5–6 mm. longae. Receptaculi paleae 6 mm. longae. Flores radii circiter 13, ligulis 6 mm. longis bidentatis flavis. Flores disci paleas aequantes. Achemia glabra tuberculosa, in radio triquetra nervata oblonga 4 mm. longa, aristis subaequalibus 2–3 mm. longis, in disco oblanceolata absque auriculis 1 mm. longis 2.5 mm. longa nigra, alis e basi 0.5 mm. latis conspicue pectinato-fimbriatis ciliolatis. Semen in radio obovato-oblongum 2.5 mm. longum subtriquetrum, in disco elongato-pyriforme 2 mm. longum. Achenia nonnulla interdum vacua tenuiter alata, auriculis ad aristas reductis.

San Jerónimo, Chiapas, Mexico, 1907, *G. N. Collins* et *C. B. Doyle*, n. 27. —Exemplum typicum in herbario Musei Nationalis sub numero proprio 693246 vidi.

Physalis porphyrophysa Donn. Sm.—Frutescens. Folia lanceolato-elliptica vel -oblonga utrinque acuminata integra supra glabrescentia subtus praesertim nervis strigilloso-pubescentia. Pedicelli 4-fasciculati. Calyces fructiferi maximi oblongo-ellipsoidei purpurei. Bacca calyce 4–5-plo superata.

Frutex 2–3-metralis (cl. *Pittier* in schedula), ramulis lignosis stramineis striatis glabrescentibus, ad apicem versus tetragonis et pube simplice vestitis. Folia tantum superiora suppetentia 4–6.5 cm. longa 1.2–2 cm. lata in petiolum 7–11 mm. longum pubescentem decurrentia, nervis lateralibus utrinque 6 subtus fuscis. Pedicelli solum fructiferi visi plerumque 4-fasciculati rarius singuli 1.4–1.7 cm. longi retroflexi pubescentes. Calyx fructifer membranaceus 4–5 cm. longus 1.7–2 cm. latus basi intrusus pentagonus 10-costatus reticulatus saturate purpureus, dentibus porrectis orificium claudentibus triangularibus 4 mm. longis muticis margine pubescentibus. Bacca aurantiaca 11 mm.-diametralis, seminibus numerosis obovato-compressoque-globosis leviter rugosis. Flores desiderantur.—Species ob inflorescentiam fasciculatam anomala.

Prope oppidulum Zacapa, Depart. Zacapa, Guatemala, alt. 200–400 m., Dec. 1906, *H. Pittier*, n. 1754.—Typus in herbario Musei Nationalis numero proprio 578148 signatus asservatur.

Diastema micranthum Donn. Sm.—Folia ex ovali ovata acuta basi rotundata crenulata supra sparsim bulboso-pilosa subtus nervis neglectis glabrescentia. Pedunculi axillares 2–3-ni petiolo longiores florem subaequantes uniflori, floribus minimis. Corollae tubus segmenta calycina lanceolata bis superans basi aequalis subrectus lobis propriis aequalibus pluries longior.

Repens decumbens stoloniferum dichotomo-ramosum. Caules ascendentes 4–5 cm. longi uti petioli pedunculi calyces pilis hyalinis articulatis villosi. Folia 3.5–6 cm. longa medio vel infra medium 2–3 cm. lata subtus pallidiora, nervis subtus fusco-pilosis, lateralibus utrinque 8–9, petiolis 4–8 mm. longis. Pedunculi basi bracteis binis foliaceis 3 mm. longis fulti 6–9 mm. longi, communi obsoleto. Calycis segmenta 4 mm. longa acuta tubo bis longiora. Corollae (in sicco pallidae) tubus 9 mm. longus supra ovarium leviter contractus sursum parum ampliatus vix pilosus, lobis 1.5 mm. longis foris pilosis. Stamina inclusa, antheris liberis transversim ovalibus, loculis orbicularibus. Disci glandulae lineares ovario semiadnato paulo breviores. Stylus corollae aequilongus, stigmatis lamellis ovalibus 1 mm. longis. Capsula semi-infera globosa 3 mm.-diametralis subglabra.

In collibus apud Jérico, Llanuras de Santa Clara, Costa Rica, alt. 400 m., Jul. 1899, *H. Pittier*, n. 7602 ex Pl. Guat. etc. quas ed. Donn. Sm. (n. 13420 herb. nat. Costaricense).

Episcia (§ CYRTODEIRA Benth.) **acaulis** Donn. Sm.—Caulis obsoletus. Folia ad nodos radicantes pluriconferta ex ovato oblongo-elliptica acuta basi rotundata vel acuta crenulata subtus vinicoloria utrinque versicoloria. Pedunculus solitarius uniflorus. Calycis colorati obliqui segmenta 4 breviter oblonga, quintum deflexum lineare. Corollae tubus basi saccatus rectus sursum sensim ampliatus, limbi patentis lobi inaequales suborbiculares tubo dimidio breviores.

Caespitosa (ex *Tonduz*), prostrata repens dichotomo-ramosa aeque ac petioli et pedunculi pilis fuscescentibus articulatis glanduliferis villosa. Folia plerumque usque ad 7–9 in rosulam conferta 3–5 cm. longa 2–2.5 cm. lata supra bullata utrinque sparsim breviterque bulboso-pilosa in area media utriusque paginae argenteo-picta, nervis lateralibus utrinque circa 7, petiolis 1–1.5 cm. longis. Pedunculus 16 mm. longus. Calycis segmenta vinicoloria sejuncta 7 mm. longa obtusa integra, posticum 1.5 mm. latum ceteris dimidio angustius. Corollae fere glabrae in sicco albidae tubus 26 mm. longus in saccum 4 mm. longum deorsum productus basi 3 mm. latus faucibus intus puberulis 8 mm. latus, limbus lobis 13 mm. longis 16 mm. latis computatis 3.5 cm.-diametralis. Stamina ad 6 mm. supra basin corollae inserta, filamentis 11–13 mm. longis, antheris oblongis 2 mm. fere longis 1 mm. latis. Disci glandula unica 1.5 mm. longa emarginata. Ovarium oblongo-ovoideum pilosum. Stylus stigmatis lamellis 2 ellipticis vix 1 mm. longis additis 19 mm. longus. Capsula ignota.—*E. lilacinae* Hanst. floribus paraffinis differt praesertim habitu.

Ad ripas fluminis Las Vueltas, Tucurrique, Prov. Cartago, Costa Rica, alt. 635 m., Mart. 1899, *Adolfo Tonduz*, n. 13167.

EPISCIAE clavis species Centrali-Americanas ad facile dignoscendas.

I. Fruticosae.
  A. Calycis laciniae lanceolatae ..... *E. lanceolata* Hanst.
  B. Calycis laciniae lineares
    1. Petiolus lamina pluries brevior ..... *E. congesta* Hanst.
    2. Petiolus laminae aequilongus ..... *E. longipetiolata* Donn. Sm.

II. Herbaceae.
  A. Acaulis ..... *E. acaulis* Donn. Sm.
  B. Decumbens
    1. Flores subsessiles ..... *E. punctata* Hanst.
    2. Flores pedunculati
      a) Corolla coccinea ..... *E. cupreata* Hanst.
      b) Corolla lilacina
        †Folii pagina utraque unicolor ..... *E. Fendleriana*. O. Ktze.
        ††Folii pagina utraque versicolor
          *Corollae lobi integri ..... *E. lilacina* Hanst.
          **Corollae lobi dentati ..... *E. chontalensis* Hook.

Besleria (§ PARABESLERIA Hanst.) **congestiflora** Donn. Sm.—Folia disparia oblique lanceolata utrinque attenuato-acuminata calloso-serrulata pilosa. Pedicelli in axillis plurifasciculati bracteis linearibus sanguineis subaequilongi calyce breviores. Corollae decurvae tubus calyci aequilongus vix gibbus ventricosus lobis subtriplo longior. Discus exannularis uniglandularis.

Omnibus fere in partibus adpresse pilosa. Ramuli teretes ad apicem versus 5 mm. crassi rubiginosi, internodiis superioribus 2.5–4.5 cm. longis. Folium alterum altero triente majus 8.5–11 cm. longum 2.3–3.3 cm. latum tenuiter coriaceum subtus flavicans, nervis lateralibus validis utrinsecus 4 sub angulo angusto longe ascendentibus, petiolis 1.5–2.5 cm. longis canaliculatis supra glabris et sanguineis. Pedunculus nullus, pedicellis compluribus 3–8 mm. longis, bracteis 5–7 mm. longis acutis supra glabris. Calycis partiti segmenta erecta aequalia 10 mm. longa 2.5 mm. lata acuta integra supra glabra. Corolla sanguinea 12 mm. longa, tubo basi supra ovarium contracto 2 mm. lato faucibus 5 mm. lato, limbo subobliquo, lobis suborbicularibus, duobus posticis altius connatis quam ceteri 3 mm. longi triente minoribus, antico crenulato. Stamina ad 1.5 mm. supra basin corollae inserta 6 mm. longa, antheris 1 mm. latis, loculis basi conniventibus, connectivo ovali. Discus ad glandulam oblongam 2 mm. longam reductus. Ovarium pilosum, stylo 5 mm. longo rubicundo glabro, stigmate stomatomorpho. Fructus ovoideus 5 mm. longus glandulam bis excedens glabrescens, seminibus saturate sanguineis 1.5 mm. longis, funiculis brevissimis.—*B. pycnosuzygiae*

Donn. Sm. ob inflorescentiam proxima ab omnibus congeneribus disco differt.

In silvis ad La Palma, Prov. San José, Costa Rica, alt. 1459 m., Sept. 1898, *Adolfo Tonduz*, n. 12658.

Besleria (PARABESLERIA Hanst.) **trichostegia** Donn. Sm.—Folia leviter disparia ex elliptico oblanceolata acuminata in petiolum brevem angustata integra. Pedicelli in axillis paucifasciculati et petiolo et calyci subaequilongi. Calycis segmenta linearia filiforme attenuata subaequalia. Corollae vix decurvae tubus calyce subduplo longior basi subaequalis parum ventricosus lobis sexies longior. Discus ovarium semicingens.

Ramuli angulati glabrescentes 3–4 mm. crassi, superiores cum petiolis pedunculis calycibus patenter pilosi, novelli cum axillis pallide villosi, internodiis superioribus 2–2.5 cm. longis. Folia 10.5–14 cm. longa supra medium 3.5–4.5 cm. lata leviter inaequilateralia herbacea utrinque sparsim bulboso-pilosa, nervis lateralibus utrinsecus 7–9 cm. et costa subtus purpurascentibus, petiolis 6–10 mm. longis. Pedunculus obsoletus, pedicellis ebracteatis circa 8 mm. longis. Calycis partiti segmenta erecta 5–6 mm. longa herbacea conspicue ciliata. Corolla rubra 13 mm. longa supra ovarium 2.5 mm. lata faucibus 3.5 mm. lata, limbo subobliquo, lobis suborbicularibus, duobus lateralibus maximis 2 mm. longis. Stamina ad 4 mm. supra basin corollae inserta 4–5 mm. longa, antheris orbicularibus 1 mm.-diametralibus, connectivo orbiculari. Discus semiannularis crassus. Ovarium ovoideum 2 mm. longum pilosum, stylo 5 mm. longo, stigmate stomatomorpho puberulo. Fructus globosus 7 mm.-diametralis pilosiusculus, seminibus sanguineis orbicularibus vix 0.5 mm.-diametralibus.

In silvis ad Tsâki, Talamanca, Comarca de Limón, Costa Rica, alt. 200 m., Apr. 1895, *Adolfo Tonduz*, n. 9558.

BESLERIA TRIFLORA Hanst., var. **subcorymbosa** Donn. Sm.—Pedicelli 3–7 subcorymbosi pedunculo triente longiores, fructiferi remoti.

Pedunculi 1.5 cm longi, pedicellis plerumque 4–7 interdum usque ad 3–5 mm. inter se remotis, axe tortuoso. Ceteroquin cum forma typica optime congruens.

La Palma, Prov. San José, Costa Rica, alt. 1460 m., Sept. 1898, *Adolfo Tonduz*, n. 7453 ex Pl. Guat. etc. quas ed. Donn. Sm. (n. 12659 herb. nat. Costaricense).—Costa Rica, 1899, *Adolfo Tonduz* (nec loco accuratiore nec numero in schedula adnotato).

BESLERIAE clavis species Centrali-Americanas ad facile dignoscendas.

I. Pedunculi uniflori
  A. Corolla basi subaequalis
    1. Folia supra laevia ..... *B. barbensis* Hanst.
    2. Folia supra scabrido-bullata ..... *B. princeps* Hanst.
  B. Corolla calceiformis ..... *B. pansamalana* Donn. Sm.

II. Pedunculi pluriflori
  A. Pedunculus pedicellis longior
    1. Corolla erecta
      a) Corolla calycem vix superans ..... *B. macropoda* Donn. Sm.
      b) Corolla calycem bis superans
        †Calycis segmenta subulato-lanceolata .... *B. laxiflora* Benth.
        ††Calycis segmenta orbiculari ovalia ... *B. imbricans* Donn. Sm.
    2. Corolla prona
      a) Corolla cylindrica ..... *B. Wendlandiana* Hanst.
      b) Corolla infundibularis ..... *B. acropoda* Donn. Sm.
  B. Pedunculus pedicellis brevior
    1. Discus annularis ..... *B. acutifolia* Benth.
    2. Discus biglandularis ..... *B. triflora* Hanst.

III. Pedunculus obsoletus
  A. Pedicelli bracteati
    1. Bracteae oblongo-ovatae ..... *B. pycnosuzygia* Donn. Sm.
    2. Bracteae lineares ..... *B. congestiflora* Donn. Sm.
  B. Pedicelli ebracteati
    1. Corolla calyce paulo longior
      a) Calycis segmenta integra ..... *B. robusta* Donn. Sm.
      b) Calycis segmenta dentata ..... *B. columneoides* Hanst.
    2. Corolla calyce bis vel ultra longior
      a) Segmenta filiforme linearia ..... *B. trichostegia* Donn. Sm.
      b) Segmenta acute ovata ..... *B. costaricensis* Hanst.
      c) Segmenta obtuse ovalia
        †Segmenta nervosa ..... *B. hirsuta* Hanst.
        ††Segmenta enervia ..... *B. glabra* Hanst.

GESNERACEARUM sequntur quaedam species Austro-Americanae ineditae.

DIASTEMA PLATYLOMATUM Donn. Sm.—Folia dimorpha, altero oblongo-ovato alterum orbiculari-ovatum bis superante, supra bullato-scabrida subtus versicoloria. Pedicelli filiformes in axillis bini vel in pedunculo communi terminali 4-ni. Calycis segmenta

oblonga. Corollae tubus calyce bis longior basi aequalis late cylindraceus parum ampliatus lobis 3 posticis maximis bis longior. Capsula tota fere infera glandulis superata.

Repens decumbens, caule 9–13 cm. longo simplice sicut petioli pedunculi pedicelli calyces fusco-hirsuto, internodiis pluribus 0.5–5 cm. longis. Folia acuta vel acuminata basi cuneata vel obtusa crenulata subtus pilosa foveolata vinicoloria areis lateralibus albida, altero generis maximo 7–14 cm. longo 5–9 cm. lato, petiolo 3–7 cm. longo, altero 3–6 cm. longo 2.5–5 cm. lato, petiolo 1–2 cm. longo, nervis lateralibus utrinque 6–7. Pedunculus communis 1.5 cm. longus, pedicellis 2–4.5 cm. longis, bracteis obsoletis. Calycis segmenta 4 mm. longa obtusa tubo turbinato bis longiora. Corolla (in sicco dilute coccinea) pilosa 1.5 cm. longa erecta, lobis 3 posticis suborbicularibus 5 mm. longis anticos semiorbiculares bis superantibus. Stamina subinclusa, antheris per paria conniventibus ovalibus, loculis oblongo-ellipticis. Disci glandulae oblongae 2 mm. longae. Ovarium ultra medium adnatum villosum, stylo 8 mm. longo pubescente, stigmatis lamellis 1 mm. longis. Capsula obconica vertice libero convexa.

Corazón, Río Pilatón, Eucador, alt. 1000–1800 m., Jan. 1881, *F. C. Lehmann*, n. 409[a].—Río Pilatón, Eucador, alt. 1000–1800 m., Jan. 1881, *F. C. Lehman*, n. 481[a].

Isoloma (§ BRACHYLOMA Benth.) **pycnosuzygium** Donn. Sm.—Folia generis inter minima internodiis pluries longiora ovato-elliptica sursum subsensim basi contractius acuminata crenulata. Calycis segmenta linearia. Corolla calyce bis longior e basi aequali cylindraceo-infundibuliformis, lobis aequalibus. Capsula subquadrivalvis.

Frutex metralis (ex schedula Eggersiana), ramis subtetragonis uti folia subtus et petioli longe denseque ravo-villosis, internodiis 0.5–2 cm. longis. Folia in eodem jugo aequalia 4–6 cm. longa 2–2.5 cm. lata supra sericea margine erubescentia, nervis lateralibus utrinque 6–7, petiolis 0.5–1 cm. longis. Calyx turbinatus 1 cm. longus, lobis tubo dimidio longioribus erubescentibus. Corolla coccinea sparsim pilosa 2 cm. longa recta basi 3 mm. lata ore 6 mm. lata, lobis semiovalibus 2 mm. longis. Stamina ima basi corollae affixa exerta, antheris liberis ovalibus, loculis parallelis. Disci glandulae oblongae. Ovarium semiadnatum villosum, stylo 16 mm. longo pubescente, stigmate stomatomorpho. Capsula semi-infera ellipsoidea 8 mm. longa 5 mm. crassa rostrata tota septicide dimidio libero loculicide dehiscens.

Los Chorros, Venezuela, Jul. 1891, *H. F. A. Eggers*, n. 13078.

Isoloma (§ BRACHYLOMA Benth.) **vulcanicolum** Donn. Sm.—Folia internodiis pluries longiora disparia lanceolato-elliptica tenuiter acuminata basi acuta crenulata. Pedunculi solitarii

uniflori foliis breviores florem subaequantes. Calycis lobi semiorbiculares. Corolla calyce 5-plo longior recta cylindracea basi oreque subaequalis, lobis aequalibus puncto-maculatis. Disci glandula postica ceteris bis latior.

Suffrutex decumbens ut videtur. Caules teretes 2–4 mm.-crassi uti folia petioli pedunculi flores fusco-pilosi, internodiis 1–1.5 cm. longis. Folia ad apicem versus caulis conferta, majore quam alterus pro rata latius dimidio longiore 7.5–9 cm. longo 3–4 cm. lato, nervis lateralibus utrinque 9–10, petiolis 8–12 mm. longis. Pedunculi floriferi 5–6 cm. longi fructiferi 8 cm. longi. Calyx late campanulatus 1 cm. longus, lobis 4 mm. longis 7–9 mm. latis herbaceis. Corolla in sicco nigricans 5 cm. longa dorso et ventre leviter arcuata basi 6 mm. lata ore 9 mm. lata medio 16 mm. lata, lobis suborbicularibus 5 mm. longis, duobus posticis altius connatis. Stamina ima basi corollae inserta exerta, antheris late cordato-ovatis in orbem 6 mm.-diametralem cohaerentibus, loculis utrinque conniventibus. Disci glandulae 2 mm. longae dentatae. Ovarium duabus partibus adnatum globosum villosum, stylo glabrescente exserto, stigmate stomatomorpho 2 mm. lato. Capsula ignota.

Ad Los Motilónes, Volcán Sotará, Cauca, Colombia, alt. 3000 m., Feb. 1884, *F. C. Lehmann*, n. 3681.

Isoloma (§ BRACHYLOMA Benth.) **oblanceolatum** Donn. Sm.—Folia disparia anguste oblanceolata acuminata in petiolum sensim attenuata serrulata subtus vinicoloria. Pedunculi folia subaequantes pedicellis 4–5-nis triplo fere longiores, floribus pedicellos paulo superantibus fusco-tomentosis. Calycis segmenta ovata acuta intus vinicoloria. Corolla calyce 4-plo longior basi obliqua declinata, limbo obliquo, lobis punctato-maculatis, postico maximo orbiculari.

Ramuli subteretes et petioli pedunculi pedicelli flores pilis glandularibus nigrescentes. Folium alterum altero dimidio majus 9.5–13 cm. longum 2.5–3 cm. latum supra bulboso-pilosiusculum subtus nervis venisque fusco-pubescens, nervis lateralibus utrinque 7–8, petiolis 1–2 cm. longis. Pedunculi validi 6.5–9 cm. longi, pedicellis 2.5–3.5 cm. longis. Calyx campanulatus duabus partibus partitus, segmentis 7 mm. longis nervatis. Corolla 4 cm. longa vix ventricosa dorso convexa basi oreque 5 mm. lata medio 1 cm. lata, lobo postico 5 mm.-diametrali, ceteris semiorbicularibus. Stamina ima basi corollae affixa exserta, antheris late obtuseque triangularibus in quadram cohaerentibus, loculis apice conniventibus. Disci glandulae oblongae. Ovarium alte adnatum ovoideum cum stylo 3.5 cm. longo pilosum, stigmate stomatomorpho. Capsula ignota.

Poblazón prope Popayán, Cauca, Colombia, Mart. 1884, *F. C. Lehmann*, n. 3682.

Gesnera (§ CORYTHOLOMA Benth.) **Lehmannii** Donn. Sm.—Folia ex obovato-elliptico oblongo-elliptica apice acuta vel obtusa in petiolum brevem attenuata crenulata supra bulboso-scabridiuscula subtus tomentosa. Pedunculi in racemo utrinque bini flore triente breviores. Calyx semilobatus, lobis subdeltoideis. Corolla calyce 3-plo longior, labio superiore lobis inferioris 4-plo longiore orbiculari. Disci annularis dimidium posticum productius.

Suffrutex e basi radicante erectus simplex 6–7 dm. altus, caule terete rubido et racemo et calycibus pubescentibus, internodiis 6–14 cm. longis. Folia 5–7.5 cm. longa 2–3 cm. lata subtus flavicantia, nervis lateralibus utrinque 6–7, petiolis 3–5 mm. longis tomentosis. Racemus corollis exemptis 7 cm. longus foliaceo-bracteosus, bracteis infimis 3.5 cm. longis, superioribus 2–0.5 cm. longis, internodio infimo 4 cm. longo, superioribus 1–0.5 cm. longis, pedunculis basi minute bracteolatis, altero florifero 2 cm. longo, altero juniore 5 mm. longo. Calyx sanguineus campanulatus 1 cm. longus, lobis parallele nervatis. Corolla coccinea ut videtur puberula 3.2 cm. longa basi gibbosa cylindracea dorso et ventre aequaliter leviterque ampliata, labio superiore erecto 5 mm.-diametrali emarginato, inferiore crenato-trilobo, lobis vix 1.5 mm. longis. Stamina exserta, antheris in quadram cohaerentibus. Disci annulus 1.5 mm. altus emarginatus. Ovarium breviter adnatum ovoideum cum stylo 22 mm. longo pubescens, stigmate stomatomorpho. Bacca desideratur.

Plantae F. C. Lehmannianae in Colombia et Ecuador collectae, n. 7903, loco haud accuratius addicto.

Gesnera (§ CORYTHOLOMA Benth.) **Eggersii** Donn. Sm.—Folia ovato-elliptica apice obtusa basi acuminata crenulata utrinque praesertim subtus pilosa. Pedunculi in verticillis approximatis racemi utrinque 2–4-ni flore 4-plo breviores. Calyx obpyramidalis semilobatus, lobis acuminato-triangularibus apiculatis. Corolla calyce 4-plo longior, labio superiore lobos inferioris 3-plo superante latiore quam longiore.

Frutex bimetralis (ex cl. *Eggers*), rhizomate ignoto, ramulis obtuse tetragonis uti petioli et racemus rubiginoso-pubescentibus, internodiis 7–12 cm. longis. Folia 6–9 cm. longa 3–4.5 cm. lata subtus rubiginoso-reticulata, nervis lateralibus subtus tantum conspicuis utrinque 7–8, petiolis 0.5–1.5 cm. longis. Racemus corollis exemptis 3.5–5 cm. longus foliaceo-bracteosus, bracteis infimis 2.5–3 cm. longis, superioribus 1.5–0.5 cm. longis, internodio infimo 1.8–2.3 cm. longo, superioribus 5–3 mm. longis, pedunculis 9–10 mm. longis basi minute bracteolatis. Calyx sanguineus pubescens 1 cm. longus, lobis retinerviis. Corolla coccinea ut videtur puberula 4 cm. longa basi gibbosa cylindracea subrecta dorso magis quam ventre ampliata, labio supe-

riore erecto transversim ovali 6 mm. longo 8 mm. lato emarginato, inferiore arcuatim trilobo. Stamina exserta, antheris ovalibus in quadram 3 mm. longam atque latam cohaerentibus. Disci glandula postica 1.5 mm. longa bis latior, additis 3 parvis dissitis. Ovarium leviter adnatum oblongo-conicum pilosum in stylum 2.5 cm. longum attenuatum, stigmate stomatomorpho. Capsula non suppetit.—Species praecedenti proxima.

El Valle, Venezuela, Jul. 1891, *H. F. A. Eggers*, n. 13124.

Columnea (§ ORTHOLOMA Benth.) **dictyophylla** Donn. Sm.—Folium alterum altero 10–12-plo longius sessile lineari-lanceolatum acuminatum basi obliqua obtusum integrum supra bullatum subtus sanguineum nervis venisque stramineo-sericeis reticulatum. Calycis segmenta linearia corollae trientem aequantia. Corolla gibbosa reclinata, limbo valde obliquo, lobis lateralibus galeae alte adnatis, antico lineari.

Ramuli subteretes rufo-villosi, internodiis inferioribus 3–6 cm. longis, superioribus 1–1.5 cm. longis. Folium in eodum jugo majus cum altero nano 13–17 mm. longo conforme 12–18 cm. longum 2.5–4 cm. latum e medio utrinque subsensim angustatum inaequilaterale subfalcatum coriaceum discolor supra strigillosum utroque latere circa 20–25-nervatum subtus pulchre minuteque reticulatum et foveolatum. Pedunculi solitarii 2.8–3 cm. longi sericei. Calycis partiti segmenta aequalia 1.8 cm. longa acuta stramineo-villosa. Corolla rosea pilis adspersa 5.3–5.7 cm. longa geniculatim gibbosa supra ovarium 4 mm. lata vix ventricosa dorso convexa faucibus haud contractis 10 mm. lata usque ad trientem labiata, galea quadrata 5 mm. longa atque lata emarginata, lobis lateralibus ultra dimidium galeae adnatis angulo recto acutis, antico porrecto 12 mm. longo 2–2.5 mm. lato obtuso. Genitalia galeae aequilonga pubescentia. Filamenta in vaginam 4 mm. longam liberam connatis, antheris quadratis 2 mm. longis ac latis. Disci glandula unica subquadrata 2 mm. longa emarginata. Ovarium ovoideum 4 mm. longum villosum, stigmate bilobo. Fructis ignotus.—*C. Warscewiczianae* Klotz. et Hanst. proxima; illa tamen differt foliis pro rata latioribus laevilus obsolete retinerviis denticulatis, calycis segmentis lanceolatis brevioribus, corollae lobis parum inaequalibus, antico elliptico.

Antióquia, Colombia, Sept. 1884, *F. C. Lehmann*, n. 4017.

AEGIPHILA FASCICULATA Donn. Sm. in BOT. GAZ. **57**:425. 1914.—Ope exempli fructiferi infra citati diagnosi adde: Calyx fructiferus auctus cupuliformis coriaceus verrucosus drupam globosam semi-includens, pyrenis abortu 3, seminibus ovoideis.

Ramuli digitulum crassi subtetragoni fistulosi albescentes cum foliis cymisque aetate provectiore glabrescentes. Cymae fructiferae densae semiglobosae, baccis 8–10 circiter 1 cm.-diametralibus, seminibus 5 mm. longis.

Ad fundum *Sepacuite*, Depart. Alta Verapaz, Guatemala, Apr. 1902, *O. F. Cook* et *R. F. Griggs*, n. 521.—Specimen in herbario Musei Nationalis numero proprio 408225 signatur.

Salvia (§ BRACHYANTHAE Benth.; *Angustifoliae* Benth.) **Collinsii** Donn. Sm.—Glabra. Folia ovato-lanceolata utrinque acuminata calloso-serrulata discoloria. Spicae subramosae, bracteis bracteolisque lineari- vel ovato-lanceolatis subulato-attenuatis flores subaequantibus persistentibus, verticillastris absque infimo imbricatis multifloris. Calycis labia ovata acuta mutica, posticum integrum, anticum bidenticulatum. Corolla calyce triente longior, tubo incluso.

Fruticulus 1.25–1.5-metralis dichotomo-ramosus, ramulorum internodiis 1–2 cm. longis. Folia 8–11 cm. longa 2.5–4 cm. lata sursum tenuiter deorsum brevius acuminata glaberrima subtus pallida venulis pellucidis minute areolata, nervis lateralibus utrinque 6, petiolis 1.5–2 cm. longis. Spicae pedunculo 1–1.5 cm. longo computato 6–8 cm. longae basi ima breviter ramosae bracteis lineari-lanceolatis 1.8 cm. longis costatis retinerviis fultae, bracteolis verticillastra fulcientibus ovato-lanceolatis 1.5 cm. longis parallelinerviis sicut bracteae herbaceis amplexicaulibus puberulis, floribus 1.5 cm. longis. Calyx sessilis obovoideo-tubulosus 9 mm. longus 12-nervius puberulus, labiis 3 mm. longis, denticulis anguste acutis 1 mm. longis. Corolla albida praeter galeam extus cano-pubescentem glabra 12 mm. longa, tubo ventricoso faucibus contracto. Stylus superne unilateraliter barbatus, lobo antico 1 mm. longo posticum bis superante.—Ad *S. Kellermanii* Donn. Sm. proxime accedens ab ea bracteis bracteolis floribus praesertim recedit.

Prope Pantepec, Chiapas, Mexico, Jan. 1907, *G. N. Collins* et *C. B. Doyle*, n. 213.—Typus in herbario Musei Nationalis sub numero proprio 574326 adest.

Neea (§ EUNEEA Heimerl.) **amplifolia** Donn. Sm.—Folia maxima elliptica vel oblongo-obovatoque-elliptica apice cuspidatim basi sensim acuminata herbacea supra glabrescentia subtus praesertim costa nervisque ferrugineo-pubescentia. Corymbi longe pedunculati, ramis alternis ad apicem versus congestifloris, pedicellis brevibus. Perianthium masculinum in genere longissimum anguste tubulosum infra medium ampliatum, dentibus 5 faucium diametrum fere aequantibus. Stamina 8 diadelphia, 4 longioribus ad medium perianthium attingentibus cetera bis superantibus.

Frutex 0.5–1-metralis, ramulis uti petioli paniculae perianthia ferrugineo-pubescentibus. Folia opposita, dichotomalia quaterna, per paria aequalia

19–27 cm. longa 8–9 cm. lata in cuspidem tenuem 10–13 mm. longam contracta basi breviter vel longe acuminata in petiolum 2–3 cm. longum decurrentia, nervis utrinque lateralibus 10–12 arcuatim ascendentibus subtus tantum perspicuendis, interjectis aliis minoribus. Pedunculi e dichotomiis oriundi 6–12 cm. longi, corymbis cymosis 4.5–7 cm. longis, ramis infimis 3.5–4.5 cm. longis patulis, bracteis cymulas fulcientibus oblongo-ovatis 2 mm. longis, pedicellis 1–3 mm. longis, bracteolis sub flore 3 ovatis 1 mm. longis persistentibus. Perianthium nonnisi masculinum cognitum in vivo latericium (cl. *Pittier* in schedula) 10–11 mm. longum dimidio superiore 2 mm. latum inferiore 3 mm. latum, dentibus oblongo-triangularibus 1.5 mm. longis. Stamina majora 5 mm. longa, minora 2–2.5 mm. longa, antheris auranteis 1 mm. longis, loculis obliquis. Ovarii rudimentum obsoletum.—Perianthium femininum et anthocarpium desiderantur.

In silvis ad ripas fluminis *Hondo* prope Madre de Dios, Comarca de Limón, Costa Rica, alt. 200 m., Nov. 1896, *H. Pittier*, n. 10356.—In silvis apud *Las Vueltas*, Tucurrique, Prov. Cartago, Costa Rica, alt. 650–700 m., Feb. 1899, *Adolfo Tonduz*, n. 13020.

Pleuropetalum tucurriquense Donn. Sm.—Folia lanceolato-elliptica utrinque acuminata integra. Paniculae fusco-pubescentes, floribus pedicellatis. Perianthii segmenta ovato-orbicularia. Stamina 6–7 disci margini inserta, filamentis liberis complanatis elongato-triangularibus. Ovarium globosum, stylo obsoleto, stigmatibus 4. Semina obovato-orbicularia.

Arbusculus, ramulis glabris uti paniculae axes fusco-pubescentes sulcatis striatis lineolatis. Folia tenuiter herbacea supra vix puberula subtus glabra et pallidiora 11–18 cm. longa 4.5–6.5 cm. lata apice contracto-acuminata in petiolum 2–3 cm. longum angustata, nervis utrinque lateralibus fortioribus 12–14 subtus tantum conspicuis. Paniculae terminales et ex axillis foliorum superiorum reductorum oriundae pedunculo subaequilongo computato 3.5–6 cm. longae densiflorae, bracteis ovatis 1.5–2 mm. longis pedicellos subaequantibus, bracteolis sub flore 2 ovatis 1 mm. longis, floribus in vivo flavescentibus (cl. collector in schedula). Perianthii segmenta 2.5 mm. longa 2 mm. lata, fructifera erecta. Stamina plerumque 6, filamentis 1.5–2 mm. longis basi 0.7–0.9 mm. lata, antheris cordato-ovatis 0.5 mm. longis. Discus 1.5 mm.-diametralis. Ovarium 1.5 mm. altum obtusum, stigmatibus brevibus erectis. Bacca in vivo coccinea (cl. collector in schedula) 5 mm. diametralis, seminibus compressis 1.5 mm. longis basi obliquis funiculum subaequantibus.—Species *P. costaricensi* Herb. Kew. ex Hemsl. arcte affinis videtur.

In silvis apud *Las Vueltas*, Tucurrique, Prov. Cartago, Costa Rica, alt. 650–700 m., Mart. 1899, *Adolfo Tonduz*, n. 13017.

Baltimore, Md.

NOTES ON THE ANATOMY OF THE YOUNG TUBER OF IPOMOEA BATATAS LAM.[1]

FLORENCE A. MCCORMICK

(WITH EIGHT FIGURES)

Aside from the interest in it as an economic plant and in the diseases which are so destructive to it, sweet potato (*Ipomoea Batatas* Lam.), like many of the Convolvulaceae, has an unusual structure in its thickened roots. The anatomy of certain thickened stems and roots has been investigated; but, so far as the writer has been able to discover, *Ipomoea Batatas* has received little attention.

Historical

The sweet potato has many scientific names (**1**, p. 323), among which *Ipomoea Batatas* Lam. (**6**), *Batatas edulis* Choisy (**1**), and *Convolvulus Batatas* Linn. (**5** and **12**) are the most familiar. The origin of *I. Batatas* is unknown (**7**), but records of its history in early literature have been written by DECANDOLLE (**4**), GRAY and TRUMBULL (**8**), and STURTEVANT (**19**).

DECANDOLLE (**4**) cites TURPIN (**20**) as having produced convincing figures showing that the thickened underground parts of *I. Batatas* are roots and not stems. The figures are those of entire tubers, both young and old, and they are given for comparison with the stem tubers of *Solanum tuberosum* and *Helianthus tuberosus*. With the rarest exceptions, the tubers of the sweet potato have been considered roots, but KAMERLING (**10**) has recently taken up the question anew. He reviews the literature in which the sweet potato is mentioned as having thickened roots, and names HAAK as a writer who considers these tubers thickened stems. Though KAMERLING did not investigate the young tuber, he regards the tuber of the sweet potato as a thickened stem and not a root, and gives figures upholding this view. Following KAMERLING, TUYIHUSA (**21**) essentially agrees with him.

[1] Contribution from the department of Agricultural Botany, Nebraska Agricultural Experiment Station.

This is the extent of the literature bearing directly on the anatomy of the tuber of *I. Batatas*, but other species of the Convolvulaceae have been studied, and in addition fleshy roots in other families, some of which to a certain degree resemble structurally the fleshy root of *I. Batatas*.

In 1870, VAN TIEGHEM (**22**) studied the roots of *Convolvulus tricolor*. He states that there are 4 rays of xylem, and that the lateral roots are formed in 4 rows corresponding to these rays. He describes and figures a tetrarch root and also the secondary tissues which are formed later. Here, also, there is a separation of the vessels by thin-walled parenchyma cells, such as may be seen in the early stages of thickening of the root of *I. Batatas*.

SCHMITZ (**15**), in his extensive study of the roots of the Convolvulaceae, omitted *I. Batatas*. Of those which he investigated, *Radix Scammonia*, the fleshy root of *Convolvulus Scammonia*, and *I. Turpethum* most closely resemble *I. Batatas*. He discusses the laticiferous vessels and states that they develop directly from the cambium and not from sieve tubes, as stated by A. VOGL.

WEISS (**23**) did not consider the Convolvulaceae in his studies of fleshy roots, but his descriptions and figures of *Bryonia dioica* show a concentric arrangement of cambium around strands of xylem, similar to that found in the thickened root of *I. Batatas*.

PETERSON (**13**) investigated *I. Batatas* as to the bicollateral structure of the stem; but he did not discuss the root. He mentions the internal phloem of the stem as being strongly developed, and this feature is also characteristic of the older roots.

DEBARY (**3**) reviews SCHMITZ's work, but adds nothing of importance concerning the anatomy. He makes a distinction between the laticiferous tubes, such as are found in the Euphorbiaceae, and the resin sacs of the Convolvulaceae.

SCOTT (**16**), in his paper on the anatomy of *Ipomoea versicolor*, considers chiefly the anomalous structure found in the transition region between the bicollateral stem and the root.

CZAPEK (**2**) reviews the literature on the laticiferous system in the Convolvulaceae. He studied the development of the system in many species, and, with the exception of *Dichondra*, he found cross-walls always present.

SOLEREDER (18) likewise refers to the work of SCHMITZ, and he gives a figure of the cross-section of the root of *Convolvulus Scammoniae*, which also has concentric layers of cambium surrounding strands of xylem.

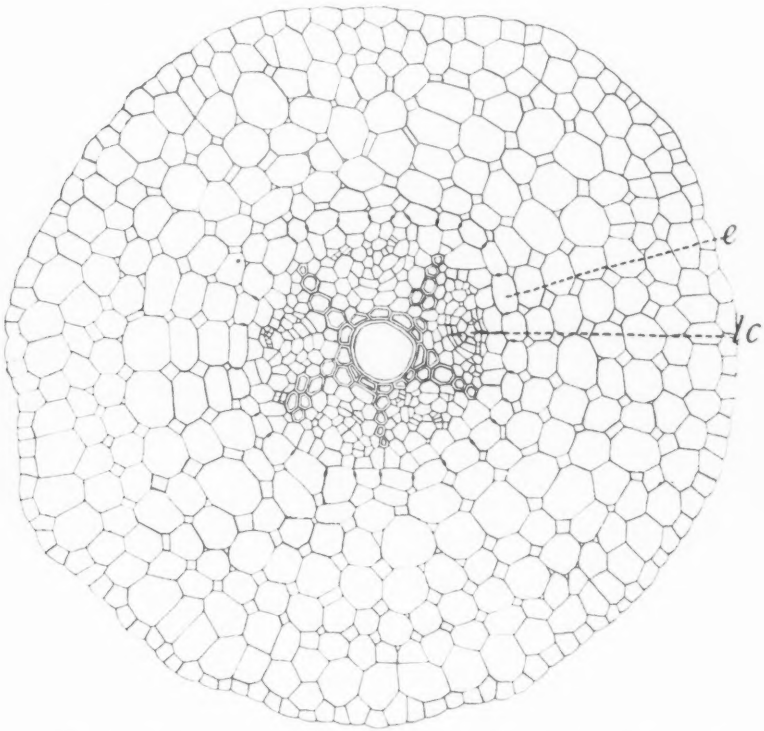

FIG. 1.—Transverse section of young root: *e*, endodermis; *lc*, laticiferous cell; ×188.

HABERLANDT (9) cites CZAPEK's work, and in brief he characterizes the laticiferous tubes of the Convolvulaceae as follows: "Ihr Inhalt besteht aus einem Plasmaschlauch und Milchsaft von unbekannter Zusammensetzung. Nach beendtem Langswachstum des betreffenden Internodiums werden die Schlauchreihen entleert und zusammengepresst."

REED (14), in his studies of tubers, considers only the stem tubers of *Solanum tuberosum* and *Helianthus tuberosus*.

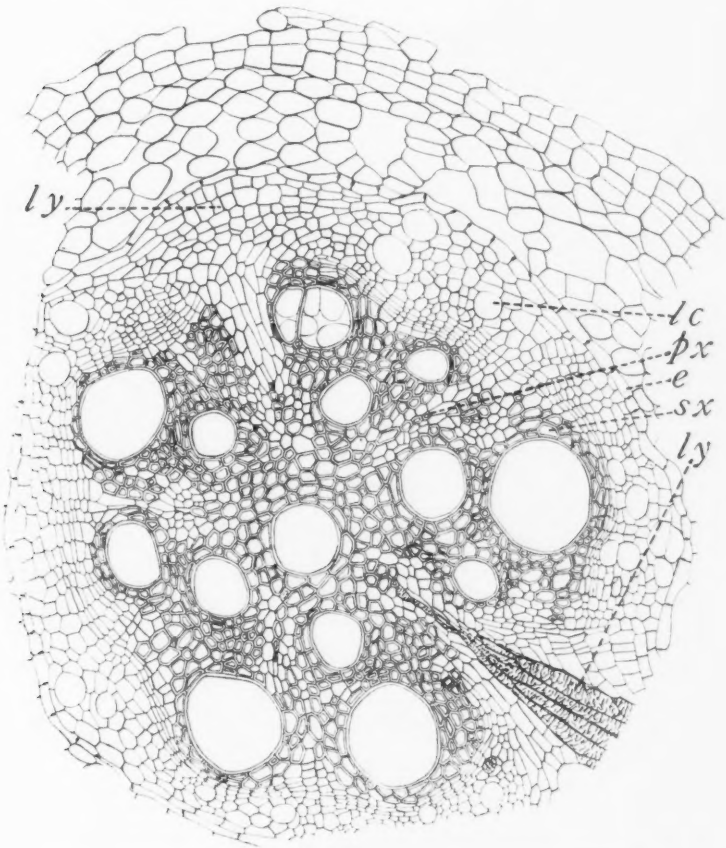

FIG. 2.—Transverse section of root showing secondary thickenings: *e*, endodermis; *lc*, laticiferous cell; *px*, protoxylem; *sx*, secondary xylem; *ly*, lateral root; ×155.

KOKETSU (11) is one of the most recent investigators of laticiferous vessels and cells, and, though the paper itself was not at hand, a review states that his results uphold those of former workers. He also gives a chemical analysis of the lactic fluid.

Investigation

Sections from many varieties of the sweet potato were examined, but the present study is confined to the Yellow Jersey. Although a comparative study was made of all stages of roots, from

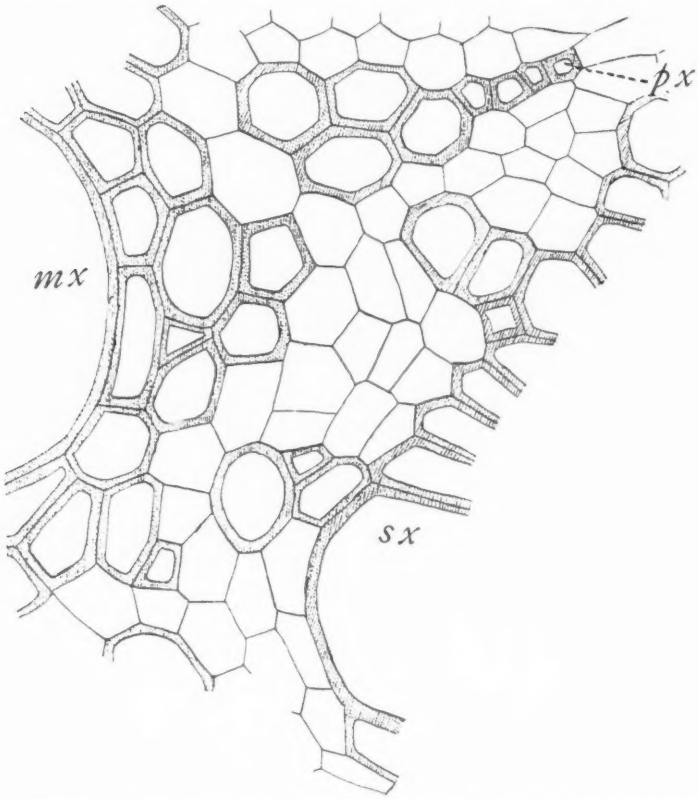

FIG. 3.—Part of transverse section of root showing beginning of activity of parenchyma: *px*, protoxylem; *mx*, metaxylem; *sx*, secondary xylem; ×810.

those showing no thickening whatsoever to the mature tuber, only the young tubers are important, for through them alone may one expect to be able to interpret the structure of the mature potato. Fig. 1 represents a freehand section of a living root; but, with that

exception, the material was killed in chromo-acetic and imbedded in paraffin. Young tubers were cut in serial sections, beginning at the stem and extending beyond the region of greatest thickening of the root. With the exception of fig. 1, all figures are

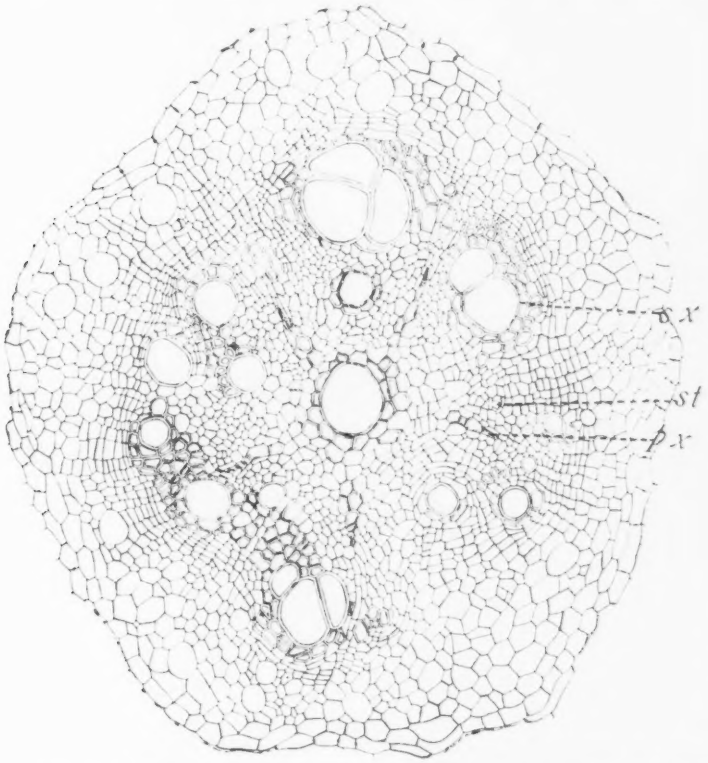

FIG. 4.—Transverse section of stele of root showing separation of xylem by parenchyma: *px*, protoxylem; *st*, sieve tube; *sx*, secondary xylem; ×155.

intentionally from the same tuber, but sections from many other tubers verify the essential features of the results here given. Some distortion must necessarily accompany such localized and greatly increased amount of thickening, but in that respect only does the structure of the fully matured tuber differ from that shown in

fig. 8. In this study no attempt was made to trace the relationship between the vascular system of the stem and that of the root, as has been done by SCOTT and BREBNER (**17**) and others in some plants having bicollateral stems

PRIMARY STRUCTURES.—The smallest roots of *I. Batatas* are frequently triarch or tetrarch; but the large roots are polyarch, chiefly pentarch or hexarch. In the young root there is usually a solid arrangement of vessels with no thin-walled parenchyma between them, and the phloem is well defined between the rays. Laticiferous cells are early distinguished (fig. 1, *lc*). The pericycle consists of a single layer of cells. The endodermis has sharply defined Casperian bands, and the remaining cells of the cortex are large and have conspicuous intercellular spaces between them.

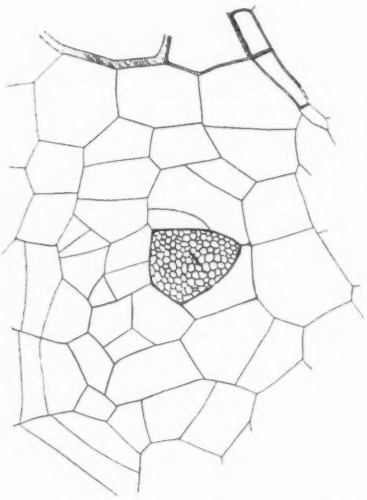

FIG. 5.—Phloem showing a horizontal sieve plate; ×1680.

SECONDARY STRUCTURES.—Cambium is organized very soon, and there is formed an extensive secondary growth which in every respect is like the secondary growth common in roots (fig. 2). The secondary xylem forms solid masses around the primary xylem; but wherever a lateral root has been formed, there is a break in the secondary xylem directly opposite the ray, for the lateral roots connect directly with the protoxylem points. These breaks, like greatly widened medullary rays, extend for some distance on each side of the place of attachment of the lateral root. It was long ago shown (**22**) that there may be as many rows of lateral roots as there are protoxylem points, and this explains the definite rows of lateral roots seen even in the fully matured potato. The amount of the secondary xylem probably is largely dependent upon conditions for growth. One root, which had grown above ground

and was quite green, had an excessive amount of secondary xylem compactly arranged around primary xylem. The structure, such as shown in fig. 2, extends in this particular root about 6 cm. beyond the place of attachment of the root of the stem, but within a short distance from this point thin-walled parenchyma between the vessels becomes active (fig. 3). The parenchyma rapidly increases in amount and separates the xylem more and more into strands, consisting of one to several vessels in a strand (fig. 4). Around each strand the parenchyma is organized into concentric layers of cambium. These secondary cambiums are capable of forming both xylem and phloem, though the primary cambium has not in the meantime become wholly inactive, but throughout the growth of the root continues forming scattered strands of xylem and phloem, each of which in turn becomes surrounded by a cambium. Tyloses are common and often the vessels are completely filled with them.

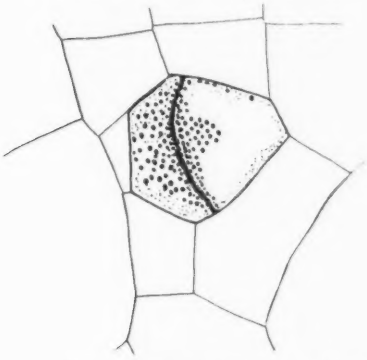

FIG. 6.—Sieve tube with inclined sieve plate; ×1680.

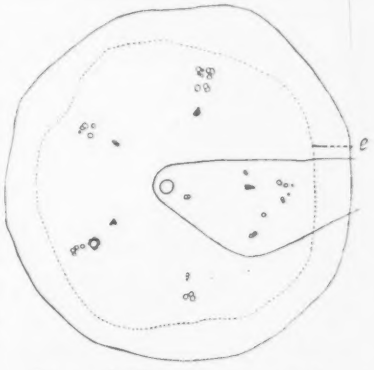

FIG. 7.—Outline of transverse section of root showing the region of fig. 8: *e*, endodermis; ×35.

PHLOEM.—The phloem is rich in sieve tubes with prominent companion cells. The sieve plates are horizontal (fig. 5) or sharply inclined, so that in transverse sections they may be readily overlooked (fig. 6). Interxylary phloem appears very soon after the thin-walled parenchyma becomes active between the vessels, and apparently it may be formed before a definite cambium is organized (fig. 5). Even in

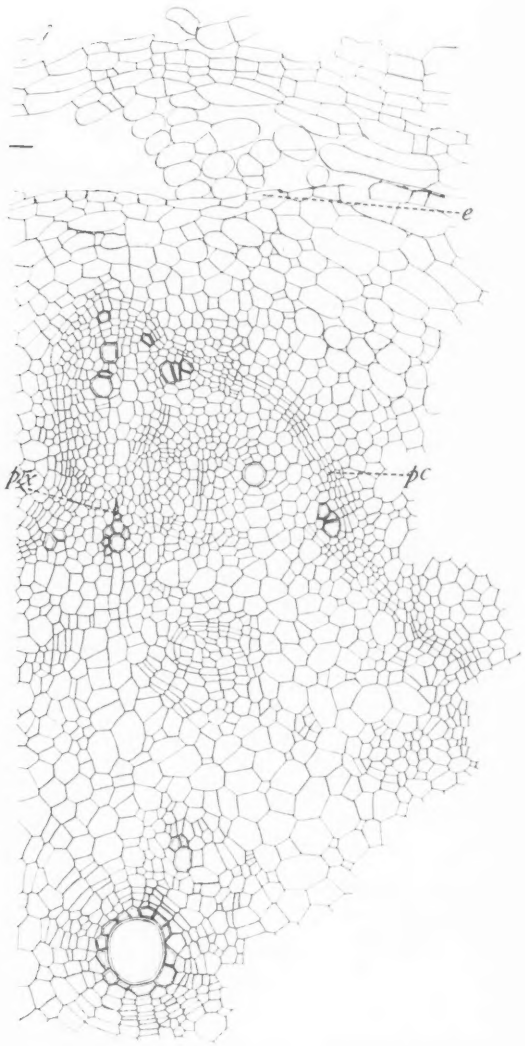

FIG. 8.—Part of transverse section of root at greatest diameter: *e*, endodermis *px*, protoxylem; *pc*, primary cambium; ×155.

a mature tuber strands of phloem unaccompanied by xylem are common.

In the young roots of *I. Batatas* the laticiferous cells are sharply delimited; but in the older tubers, in which the parenchyma cells are larger, they are not readily distinguished. The cross-walls are numerous and are not resorbed.

Summary

1. The larger roots of *Ipomoea Batatas* Lam. are polyarch, chiefly pentarch and hexarch.

2. Secondary thickenings occur in the usual way and there is formed a massive structure of secondary xylem.

3. Secondary cambiums are organized around strands of xylem and phloem which are separated by thin-walled parenchymatous cells. The primary and secondary cambiums are capable of forming xylem and phloem in isolated strands. One may reasonably expect that, if the conditions for growth are especially favorable, the secondary cambiums may be organized earlier.

4. A section of a mature tuber shows a structure consisting chiefly of parenchyma, and mingled with the parenchyma are strands of xylem, which consist of one to several vessels, and may or may not be accompanied by phloem. Each strand is surrounded by a cambium. There may also be seen strands of phloem unaccompanied by xylem. This structure may be definitely traced back to the radial protostele.

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XEROFOTIC MOVEMENTS IN LEAVES

FRANK C. GATES

(WITH EIGHT FIGURES)

DEFINITION.—The word *xerofotic*, expressing the ideas of dryness and light, gives a clue to the meaning the word is intended to connotate, namely, dryness caused by light. Xerofotic movements, therefore, are paratonic movements resulting from certain drying effects produced through the action of light. They are manifested by an upward bend in the leaflets or a curling or rolling upward of the blade.

MECHANISM.—The side of a structure facing the sun becomes warmer than the opposite side. Under these conditions, other things being equal, there is a relatively greater loss of water from the exposed side. When the water is not replenished as fast as it evaporates, a greater lowering of the turgidity in the cells of the upper side ensues. The greater pressure exercised by the more turgid cells of the lower side causes the structure to bend or roll in the direction of the exposure. In the case of the most conspicuous examples, the leaflets of leguminous plants, the result of this action of light is an upward movement of the leaflets. The base of the leaflet is the seat of the differential turgidity.

No amount of heat or rapid transpiration is sufficient to cause the xerofotic movement unless there is also a difference in turgidity caused by one-sided illumination. This movement is entirely distinct from the collapse or wilting caused by too great a drying, and from the photeolic, or so-called sleep, movements.

CLASSIFICATION.—Two kinds of xerofotic response were observed: the *localized* response, in which the differential turgidity is largely confined to a small region, as, for example, the pulvini of leguminous leaflets; and the *generalized* response, in which the differential turgidity is spread over the leaf, causing the blade to curl or roll upward. Cases in which the leaves roll downward or underneath must be considered as wilting and not as xerofotic responses.

OCCURRENCE.—Examples of the generalized response were noted in the monocotyledonous families Poaceae, Araceae, Marantaceae, and Zingiberaceae. At different times the leaves might be rolled in either direction. Whenever the rolling is upward it should be considered as a xerofotic response, when downward, the result of wilting. Examples of the localized response, with which this article deals, were furnished by all the Leguminosae under observation. Such response is not limited to this family, however,

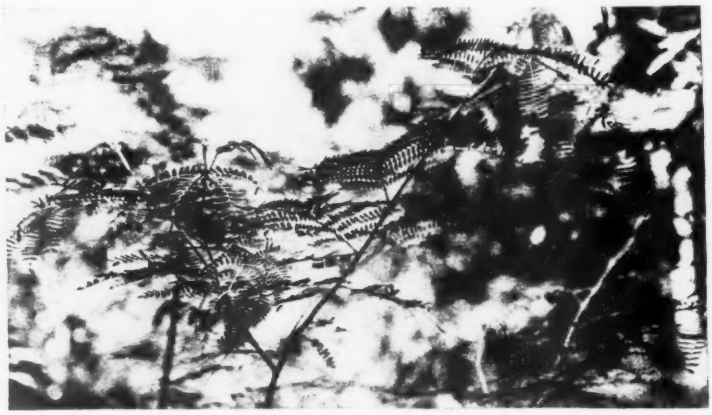

FIG. 1.—*Leucaena glauca*, showing leaflets in the horizontal position, the normal day position; Los Baños, P.I., July 18, 1914.

but is shown by *Ipomoea Pes-caprae* of the Convolvulaceae, and as well in a few other families of plants, particularly those whose species have compound leaves, as in the Meliaceae and Oxalidaceae. While xerofotic responses were noted also in *Abrus precatorius*, *Acacia farnesiana*, *Aeschynomene indica*, *Albizzia procera*, *Bauhinia malabirica*, *Bauhinia* sp., *Caesalpinia pulcherrima*, *Canavalia ensiformis*, *C. lineata*, *Clitorea ternata*, *Delonix regia*, *Derris elliptica*, *Desmodium gangeticum*, *D. laxiflorum*, *D. pseudotriquetrum*, *D. triflorum*, *Enterolobium saman*, *Erythrina indica*, *Mezoneurum glabrum*, *Mucuna nigricans*, *M. longipedunculata*, *Pithecolobium dulce*, *P. subacutum*, *Pterocarpus indicus*, *Sesbania grandiflora*, *S. cannabina*, *Tamarindus indica*, *Teramnus labialis*, *Vigna lutea*,

and *Voandzeia subterranea*, all belonging to the Leguminosae, the following were selected for study on account of their suitability and convenience: *Gliricidia sepium* of the subfamily Papilionatae, and *Leucaena glauca* and *Mimosa pudica* of the subfamily Mimosatae.

Amount of movement.—As the normal day position of the leaflets of legumes is a plane at approximately right angles to the light, the amount of movement can easily be expressed as

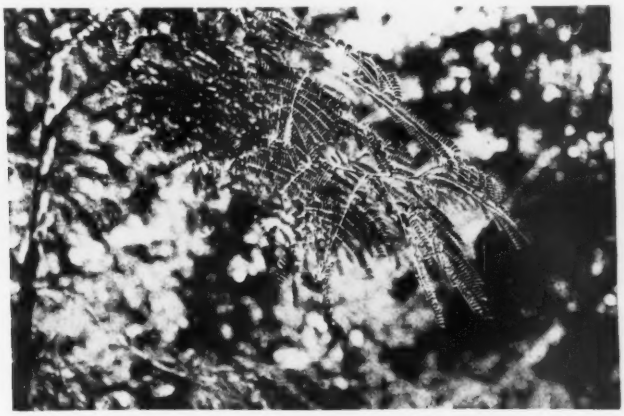

Fig. 2.—*Leucaena glauca*, showing leaflets in the xerofotic position, assumed under stimulation of direct sunlight; Los Baños, P.I., July 29, 1914.

the amount of divergence from the horizontal. Whether the night position of the leaflets is erect or drooping, the xerofotic position is between 45° and 70° above the horizontal (figs. 1 and 2). When the night position of the leaflet is above the horizontal, as is the case with many members of the Mimosatae, the xerofotic position differs in not exceeding 70° above the horizontal and in the absence of a forward movement often a part of the photeolic response. The horizontal position is assumed always between the xerofotic and the night positions.

Inequality and irregularity of the movement.—Generally speaking, the upward bend is equal in each leaflet of a pair and likewise in a series of pairs. The exceptions noted in nature and

produced by experiment make the general nature of the phenomenon clearer. As the intensity of the sun in the east increases, the west leaflets of a leaf, oriented north and south, usually exhibit the xerofotic movement before the east leaflets. It was demonstrated experimentally that in this response the paired condition of the leaflets is of less importance than in other movements. Even in the very sensitive *Mimosa pudica*, one leaflet of a pair is frequently bent more in xerofotic response than the other; while

FIG. 3.—*Leucaena glauca* against the sky, showing amount of light cut off by leaflets in the horizontal position; compare with fig. 4; Los Baños, P.I., July 29, 1914.

in the disturbance of turgidity caused by shock, the pairs act equally and simultaneously. This suggests that xerofotic conditions of unequal turgidity are very little, if at all, transmitted. All the leaflets of a compound leaf do not necessarily respond equally. Sometimes there is an obvious reason, for the basal leaflets are shaded. In other cases, only the hypothesis that the the basal leaflets are better and more quickly supplied with water to equalize the turgidity seems to explain the discrepancies in movement.

SEASONAL RELATIONS.—This movement is not peculiar to any season, but is present throughout the year. In the dry season the xerofotic position is regularly assumed a short time after the sun

has been shining directly on the leaflet. In exposed plants the movement is nearly certain to have taken place by 8:30 in the

FIG. 4.—*Leucaena glauca* against the sky, showing amount of light cut off by leaflets in the xerofotic position; compare with fig. 3; Los Baños, P.I., July 29, 1914.

FIG. 5.—*Gliricidia sepium* shortly after a rain; the majority of the leaflets are in the horizontal position; a few in the upper and in the right-hand part of the figure are resuming the xerofotic position; Los Baños, P.I., July 20, 1914.

morning. During the rainy season, since the sun is out less, the assumption of the xerofotic position is less frequent.

RESULTS AND ADVANTAGES.—The obvious result of the xerofotic position is to decrease the amount of direct radiant energy received per unit area of leaf. This reduces the harmfulness of too great sunlight upon the chlorophyll, as well as reducing the transpiration during the critical time of day. Its frequency is undoubtedly a valuable asset to the family Leguminosae, one of the most important plant families and the richest in species in the tropics.

FIG. 6.—*Ipomoea Pes-caprae* growing in the shade, showing leaves in spread-out position; Taal Volcano, P.I., March 7, 1915.

The assumption of the xerofotic position permits a great deal more light to come through the leaf layer. This is admirably shown in figs. 3 and 4 of *Leucaena glauca*, taken on the same day from the same spot; fig. 3 when the leaflets were in the horizontal position; and fig. 4 three hours later, after the leaflets had assumed the xerofotic position.

EXPERIMENTATION.—That this class of movements might not rest solely on observation, a number of experiments were performed at Los Baños, Philippine Islands, during 1913 and 1914. Screens were interposed between the sun and plants of *Gliricidia sepium*, *Leucaena glauca*, and *Mimosa pudica*, whose leaflets were in the xerofotic position. In every case the leaflets fell back to the horizontal position. Occasionally as short a time as 5 minutes

was sufficient to bring about the change, but usually it took about 20 minutes. Upon taking away the screen the xerofotic position was gradually resumed. When the sun was very hot a little upward curling of the outer end of the leaflet was noticed before the complete assumption of the xerofotic position.

While the screen experiments clearly indicated that drying effects dependent upon exposure to sunlight were fundamental, other experiments sought to produce drying effects independently

FIG. 7.—*Ipomoea Pes-caprae* growing on the open strand, showing leaves in the xerofotic position, assumed during the hours of strong sunlight; Taal Volcano, P.I., April 18, 1914.

of the sunlight. Two of the common laboratory drying agents, absolute alcohol and xylol, were employed. Several legumes were experimented with, but in the majority of cases, the delicateness of the rachis and the small size of the pulvinus made the experiments a failure. At length, however, a suitable plant was found in *Gliricidia sepium*, in which the leaflets, rachis, and pulvini are large and coarse (fig. 5). In successive experiments, both absolute alcohol and xylol were carefully applied to the upper side of the pulvinus with a small pointed brush. As the drying agent withdrew water locally from the upper cells of the pulvinus, the xerofotic position of the leaflet was gradually assumed. The experiments

were conducted both out of doors and in the laboratory, with the leaf right side up and upside down. In each case the effect of the local withdrawal of water was the assumption of the xerofotic position.

In additional experiments, branches of trees were cut away so that shade leaves, in which no previous xerofotic movement had been noted, were exposed to the full sun. In all such cases the xerofotic position was soon taken. A burning-glass, used to intensify

FIG. 8.—*Canavalia lineata* growing on the strand, showing leaflets in the xerofotic position; Taal Volcano, P.I., March 7, 1915.

the action of the sun on leaflets which had been artificially shaded, brought about a more rapid assumption of the xerofotic position.

Both shade and xylol experiments were conducted upon the convolvulaceous *Ipomoea Pes-caprae*, growing on the strand of Taal Volcano, Philippine Islands (figs. 6, 7, and 8). In this case the clam-shaped simple leaf spread out under the dense shade of a screen and spread out leaves folded nearly together soon after xylol was applied to the upper part of the midrib.

Summary

1. Xerofotic movements are paratonic movements, caused by unequal drying effects in direct sunlight, manifested by an upward bend in leaflets or a curling upward of the blade. Greater turgor

of the cells of the lower side causes a movement in the direction from which the desiccating energy comes. The xerofotic position decreases the amount of direct radiant energy received per unit area of leaf, reducing the harmful action of intense sunlight upon the chlorophyll as well as checking transpiration.

2. Two classes of xerofotic response were noted. In the localized type the differential turgidity acts in a limited region, such as in the pulvini of leguminous leaflets. In the generalized type the difference in turgidity is between the upper and lower part of the blade. The localized response was characteristic of all observed species of Leguminosae, but is not limited to that family. The generalized type was noted particularly in the monocotyledonous families Poaceae, Araceae, Marantaceae, and Zingiberaceae.

3. In nature the response was brought about by direct stimulation from the sun. It was artificially simulated by the action of the chemical desiccating agents, absolute alcohol and xylol, on *Gliricidia sepium* and *Ipomoea Pes-caprae*.

4. The amount of movement varied between 45° and 70° above the horizontal. Movement took place under suitable conditions at any season. The amount of response, even in leaflets of a pair, varied under different conditions of exposure.

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PHYSICAL PROPERTIES OF SOME TOXIC SOLUTIONS

GEORGE B. RIGG, H. L. TRUMBULL, AND
MATTIE LINCOLN

This paper deals with the osmotic pressure and the surface tension of (1) water obtained from sphagnum bogs of the Puget Sound region and Alaska, (2) solutions obtained by allowing the rhizomes of *Nymphaea polysepala* Gr. to decay in water.

Osmotic pressure

The difference between the freezing point of each solution and that of pure water was determined with the Beckman apparatus. From this lowering, the osmotic pressure at 0° C. was calculated in two ways: (1) from a consideration of the relation between molar concentration and osmotic pressure[1] established directly by MORSE (**6**); (2) by substitution in the ordinary formula based on thermodynamic reasoning, namely, $P = 12.05 \times dt$ atmospheres at 0°.

TABLE I

OSMOTIC PRESSURE OF BOG WATERS

Sources	Sample obtained	Sample tested	dt	P (Morse)	P (Nernst)	M
1. Henry bog sample 1	Dec. 22, 1914	Jan. 19, 1915	0.008	80.48	73.15	0.004301
2. Henry bog sample 2	Dec. 22, 1914	Jan. 21, 1915	0.008	80.48	73.15	0.004301
3. Maltby bog sample 1	Feb. 22, 1915	Mar. 3, 1915	0.008	80.48	73.15	0.004301
4. Maltby bog sample 2	Feb. 22, 1915	Mar. 3, 1915	0.008	80.48	73.15	0.004301
5. South Mud Lake bog	Mar. 6, 1915	Mar. 13, 1915	0.009	90.55	82.40	0.004839
6. Henry bog	Feb. 23, 1915	Mar. 13, 1915	0.000			
7. Cordova (Alaska) bog	May 23, 1913	Mar. 13, 1915	0.006	60.37	54.94	0.003226
8. North Mud Lake bog	Mar. 13, 1915	Mar. 27, 1915	0.002	20.12	18.31	0.001074
9. Fauntleroy bog	Aug. 30, 1915	Sept. 7, 1915	0.002	20.12	18.31	0.001074
10. North Mud Lake bog	Sept. 1, 1915	Sept. 7, 1915	0.002	20.12	18.31	0.001074
11. Henry bog	Aug. 28, 1915	Sept. 7, 1915	0.003	30.18	27.46	0.001611
12. South Mud Lake bog	Sept. 1, 1915	Sept. 7, 1915	0.004	40.25	36.63	0.002148

In table I, dt represents the lowering of the freezing point in degrees centigrade; M represents the molar concentration of a solution of any non-electrolyte which shows the same lowering of the freezing point; P represents the osmotic pressure in millimeters

[1] These investigators found that 0.1 M sugar solutions at 0° C. give 2.462 atmospheres osmotic pressure. This corresponds to 0°.186 depression of the freezing point.

of mercury. The data are put into such form that they may be compared with the data given by LIVINGSTON (**5**) for bog waters of central and eastern United States.[2]

Duplicate series of determinations of the freezing point lowering were made for each sample reported in table I. Owing to the low concentrations of the solutions, the maximum or freezing-point temperatures remained surprisingly constant, and were read at one-minute intervals from 6 to 10 times. The deviation from the mean in each series was usually about 0°.001, seldom as high as 0°.002, the estimated reading error of the thermometer. The means of the two series agreed with each other in all cases within 0°.001, and in four cases they were identical. A hand lens (aplanatic triplet) was used in reading the scale, and care was taken to avoid parallax. The temperature of the outer bath in all of the tests except 3 was between 3°.5 C. and 3°.8 C. In the three exceptions the temperatures were 3°.4, 4°.0, and 4°.5 C.

Samples 1–8 inclusive were obtained during the rainy season or soon after its close. Each sample was obtained by cutting out the sphagnum to a depth of 30–45 cm. and dipping up the water that collected. Samples 9–12 were obtained just at the close of the dry season. Samples 9 and 11 were obtained by squeezing the water from handfuls of sphagnum obtained at 50–200 mm. below the surface of the bog. This method was used because at that time no water accumulated in a hole 1.5 m. deep in half an hour. Samples 10 and 12 were dipped up from holes cut in the sphagnum 40 cm. deep. In both of the Mud Lake bogs the height of the water table is evidently determined by the level of the adjoining lake. There is no lake adjoining either the Fauntleroy bog or the Henry bog.

The general characteristics of the sphagnum bogs of the Puget Sound region and of the Alaska coast have been described by RIGG (**7, 8**). Descriptions of the Henry bog, the Fauntleroy bog, and the Cordova bog are included in the papers cited. Maltby bog is situated in Snohomish County, Washington, about a mile

[2] LIVINGSTON's osmotic pressures are computed for 25° C.; those of the writers' are for 0° C., hence should be multiplied by $\frac{298}{273}$ for comparison with LIVINGSTON's pressures.

south of the town of Maltby. It has an area of some 60 acres. Mud Lake is situated on the west side of Lake Washington, just north of the city limits of Seattle. It is separated from Lake Washington by a narrow wave-built ridge of gravel. South Mud Lake bog is a small patch of sphagnum situated within the southern portion of the lake. North Mud Lake is larger (perhaps 15 acres in area) and lies adjacent to the north and west sides of the lake.

For comparison, the lowering of the freezing point of the waters from some lakes and springs was determined. The results are shown in table II.

TABLE II

OSMOTIC PRESSURE OF THE WATERS FROM SOME PUGET SOUND LAKES AND SPRINGS

Sources	Sample obtained	Sample tested	dt	P (Morse)	P (Nernst)	M
1. Crystal Lake	Feb. 22, 1915	Mar. 3, 1915	0.007	70.42	64.08	0.003763
2. Mud Lake	Mar. 6, 1915	Mar. 13, 1915	0.001	10.06	9.16	0.000537
3. Lake Washington	Mar. 6, 1915	Mar. 13, 1915	0.002	20.12	18.31	0.001074
4. Spring no. 1	Mar. 6, 1915	Mar. 13, 1915	0.000			
5. Spring no. 2	Mar. 11, 1915	Mar. 13, 1915	0.002	20.12	18.31	0.001074
6. Mud Lake	Sept. 1, 1915	Sept. 7, 1915	0.004	40.25	36.63	0.002148
7. Lake Washington	Sept. 1, 1915	Sept. 7, 1915	0.004	40.25	36.63	0.002148
8. Spring no. 2	Sept. 1, 1915	Sept. 7, 1915	0.004	40.25	36.63	0.002148

Crystal Lake is located in the center of Maltby bog. It is entirely surrounded by sphagnum, and has, at least at the surface, no contact with other soil. The lake has an area of about 10 acres. The water from this lake is scarcely distinguishable in appearance from that of the bog. The location of Mud Lake has already been given. Its water resembles bog water somewhat and contrasts strongly with the clear water of Lake Washington. Samples 3 and 7 were collected from Lake Washington at a point near Mud Lake. Spring no. 1 is just north of the city limits of Seattle. It is near East 65th Street and 40th Avenue N.E. It is in logged-off land which is not under cultivation. Spring no. 2 is at the head of a ravine on an unused portion of the campus of the University of Washington. It is situated in logged-off land.

The difference between the freezing point of pure water and that of solutions resulting from the decay of rhizomes of *Nymphaea polysepala* was also determined with the Beckman apparatus. The

standard solution used was that resulting from the decay of 500 gm. of the rhizome in 800 cc. of water. Table III shows the results of the test on three different solutions thus prepared.

TABLE III

LOWERING OF FREEZING POINT OF STANDARD SOLUTIONS FROM THE DECAY OF *Nymphaea* RHIZOMES IN WATER

Solution	Date of test	Lowering of freezing point
1	Feb. 24, 1915	0.097
2	Feb. 24, 1915	0.156
3	Mar. 13, 1915	0.142

The osmotic pressure of 10 per cent (1 volume of solution to 9 volumes of water), $7\frac{1}{2}$ per cent, and 5 per cent solutions of these standard solutions was calculated from the results shown in table III. These computed values are shown in table IV.

TABLE IV

CALCULATED OSMOTIC PRESSURES OF SOLUTIONS FROM DECAY

Solution	dt	P (Morse)	P (Nernst)	M
Sample 1, 10 per cent	0.010	100.63	91.6	0.005376
Sample 1, $7\frac{1}{2}$ per cent	0.007	70.42	64.08	0.003763
Sample 1, 5 per cent	0.004	40.25	36.63	0.002148
Sample 2, 10 per cent	0.016	161.0	146.4	0.008601
Sample 2, $7\frac{1}{2}$ per cent	0.011	110.7	100.7	0.005913
Sample 2, 5 per cent	0.007	70.42	64.08	0.003763
Sample 3, 10 per cent	0.014	140.9	128.2	0.007527
Sample 3, $7\frac{1}{2}$ per cent	0.010	100.6	91.6	0.005376
Sample 3, 5 per cent	0.007	70.42	64.08	0.003763

These particular dilutions are suggested because these (and in some cases greater) dilutions proved toxic to plants grown in them by RIGG (9).

Surface tension

Tests of the surface tension of bog waters were made by the Jolly method. The results are shown in table V.

TABLE V

SURFACE TENSION OF BOG WATERS

Liquid	Surface tension in dyne cm.	Surface tension in percentage of surface tension of pure water
Pure water	72.7	100
Ronald bog, sample no. 1, unfiltered	70.3	96*
Ronald bog, sample no. 2, unfiltered	72.3	99*
Ronald bog, sample no. 1, filtered	65.7	92*
Maltby bog	67.5	94*

* Computed from the data in column 1 on the basis of the surface tension of pure water given in Smithsonian table no. 141 p. 128. Rev. ed. 1897.

Tests of surface tension by the Jolly method were also made on solutions resulting from the decay of *Nymphaea* rhizomes in water. The standard solution used was that resulting from the decay of 500 gm. of the rhizome in 800 cc. of water. Table VI shows the results of the tests. Unless otherwise noted, the tests are on the standard solution. Dilutions of 10 per cent (9 volumes of water + 1 volume of solution), $7\frac{1}{2}$ per cent, and 5 per cent are so designated in the table.

TABLE VI

SURFACE TENSION OF SOLUTIONS RESULTING FROM THE DECAY OF *Nymphaea* RHIZOMES

Liquid	Surface tension in dyne cm.	Surface tension in percentage of surface tension of pure water
Sample 1	64.2	88.0
Sample 1 diluted to 10 per cent	66.9	93.0
Sample 1 diluted to $7\frac{1}{2}$ per cent	73.1	101.0
Sample 1 diluted to 5 per cent	72.3	99.0
Sample 2	60.6	84.0
Sample 3	62.9	87.0

In order to compare surface tension results obtained by the writers by the Jolly method with the results obtained by CZAPEK (3) with his apparatus, a series of alcohols were tested.

The results are compared in table VII. The first two columns show the writers' results, while the third shows CZAPEK's results.

TABLE VII

SURFACE TENSION OF ALCOHOLS

Alcohol	Surface tension in dyne cm.	Surface tension in percentage of surface tension of pure water	Surface tension from Czapek
7 per cent ethyl	55.7	76	76
13 per cent ethyl	48.9	67	65
15 per cent ethyl	45.6	63	62
15 per cent methyl	53.1	73	73
20 per cent methyl	45.6	64	67

The surface tension of 13 per cent ethyl alcohol was tested with a duplicate of CZAPEK's apparatus. The average of the tests made was 66, which lies between the results given by CZAPEK and the results obtained by the writers with the Jolly apparatus. It was thought best to use the Jolly apparatus rather than this duplicate of CZAPEK's apparatus, since in general more dependable results would thus be obtained. There are at least three sources of error in CZAPEK's apparatus: (1) the difference in the height of the water in the two sides of the manometer cannot be read any closer than 1 mm., owing to the irregular meniscus and the necessity of taking the readings just as a sudden change of height is taking place; (2) the capillary tube is immersed so slightly in the liquid that a small error in the depth to which it is immersed would make a relatively large error in the result; (3) it is an indirect method, the value for each liquid being compared with the value for pure water determined with the same apparatus, thus giving a double chance for error.

Discussion

LIVINGSTON (**5**) has published data which he summarizes as follows: "bog waters do not have an appreciable higher concentration of dissolved substances than do the streams and lakes of the same region." The following are the averages of the results of all tests of the lowering of the freezing point of bog waters and of other surface waters reported by LIVINGSTON (*loc. cit.*), and of

the results of all tests made by the writers on such waters: LIVINGSTON'S tests on bog waters, 0.009; tests by the writers on bog waters, 0.005; LIVINGSTON'S tests on other surface waters, 0.007; tests by the writers on other surface waters, 0.003. In so far as the data given can be taken to be representative of the regions, it seems that the osmotic pressure of all waters tested is lower in the region worked in by the writers than in the region in which LIVINGSTON worked. The difference between the average for bog waters and for other surface waters in the two regions is exactly the same.

LIVINGSTON (*loc. cit.*) found "practically no difference in osmotic pressure corresponding to the season." The average of the determinations made by the writers on bog waters during the rainy season and during the dry season is as follows: rainy season, 0.006; dry season, 0.002. Here, as elsewhere in this paper, figures beyond the third place are not considered significant.

FITTING (**4**) has concluded that xerophytism and difficulty in absorption do not seem to be correlated with high osmotic pressure (the writers have not seen this paper).

Whatever conclusions the writers would be justified in drawing from their data would be in substantial agreement with those of LIVINGSTON and of FITTING. That is, high osmotic pressure is not the cause of the toxicity of the waters of sphagnum bogs.

Omitting Crystal Lake (since the properties of its waters seem practically identical with those of bog waters), the comparison of the lowering of the freezing point of lake and spring waters for the wet season and the dry season[3] is as follows: average for the wet season, 0.001; average for the dry season, 0.004. This is too small a number of tests to be made the basis of any generalization as to seasonal variation in osmotic pressure in this region. The average of the limited data here cited, however, is just the opposite of the average of the data secured by TRANSEAU (**11**) for central Illinois in 1913, when there were no rains of consequence from the middle of April to the middle of September. He found that the highest osmotic pressures were recorded during the spring, when the water levels were highest, and that the lowest records were during the

[3] There was no rain for 45 days preceding the time of collection of the samples for the dry season.

middle of September, when the levels for the year were the lowest. He found that the osmotic pressure of the waters tested (expressed in mm. of mercury) varied from 59 to 407. Those tested by the writers (table II) varied from 0 to 70. The waters of the Puget Sound region are soft, possessing very little of even temporary hardness.

In so far as the data given in this paper are concerned, the seasonal variation of osmotic pressure in the waters of the sphagnum bogs in the Puget Sound region seems to be the opposite of that of the waters of springs and lakes.

The surface tension of bog water was measured in order to determine whether it might be low enough to cause exosmose from the root cells of plants growing in the bogs. BLACKMAN (1) and CZAPEK (2) find that when liquids having a surface tension of 0.66 or less (pure water being taken as 1.00) are applied to plant cells most of the cells are injured and die. The results shown in table III show surface tensions so far above 0.66 that there seems to be no reason whatever for supposing that low surface tension could be a factor in the toxicity of the waters of sphagnum bogs.

It has been noted in the field by SHERFF (10) that rhizomes of *Sagittaria* are killed when they grow into the decaying portion of the rhizomes of *Nymphaea advena*. It has also been found by RIGG (*loc. cit.*) that solutions resulting from the decay of *Nymphaea* rhizomes are toxic to *Tradescantia* cuttings and to agricultural plants, even in very dilute solution.

There is no indication in the data here published that either high osmotic pressure or low surface tension can be a factor of any importance in the toxicity of the solutions resulting from the decay of *Nymphaea* rhizomes in the extreme dilutions which proved toxic to *Tradescantia* cuttings and to agricultural plants.

Summary

1. The osmotic pressure of bog water in the samples tested was higher during the rainy season than at the close of the dry season.

2. The osmotic pressure of the waters tested from lakes and springs was lower during the rainy season than at the close of the dry season.

3. There is no indication that either high osmotic pressure or low surface tension is an important factor in the toxicity of bog water or of very dilute solutions resulting from the decay of *Nymphaea* rhizomes.

The writers wish to express thanks to Dr. F. A. OSBORN for advice on the surface tension determinations.

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FIVE UNDESCRIBED SPECIES OF RAVENELIA

W. H. Long

The five species described in this article were collected during 1914 and 1915. Three of them are from Texas, one is from Florida, and one from Arizona.

There are known now to occur in Texas 11 species of *Ravenelia*, including 3 of the new species described in this paper, namely, (1) *Ravenelia arizonica* Ellis and Ev. on *Prosopis juliflora*, (2) *R. versatilis* (Peck) Dietel on *Acacia greggii*, (3) *R. igualica* Arthur on *Acacia filiculoides*, (4) *R. texensis* Ellis and Gall. on *Acuan jamesii* and *A. acuminata*, (5) *R. fragrans* Long on *Mimosa fragrans*, (6) *R. cassiaecola* Atk. on *Chamaecrista multipinnata* (?), (7) *R. longiana* Syd. on *Cassia roemeriana*, (8) *R. papillifera* Syd. on *Cassia lindheimeriana*, and the 3 species here described: (9) *R. roemerianae* on *Acacia roemeriana*, (10) *R. morongiae* on *Morongia uncinata*, and (11) *R. thornberiana* on *Acacia constricta paucispina*. The types of 7 of these species (*R. texensis*, *R. roemerianae*, *R. thornberiana*, *R. fragrans*, *R. longiana*, *R. papillifera*, and *R. morongiae*) were collected in Texas, while the type locality of the last 4 named is Austin, Texas.

Many Mexican species of this genus undoubtedly will be found in southwestern Texas, especially in the territory lying between El Paso and Brownsville along the Rio Grande. *R. cassiaecola* is reported for the first time west of the Mississippi River, the writer having collected it at Denton, Texas.

Two closely related genera, *Neoravenelia* and *Pleoravenelia*, are also represented in this state, the former by *N. Holwayi* (Dietel) Long on *Prosopis juliflora*, and the latter by *P. Hieronymi* (Speg.) Long on *Vachellia farnesiana*. *P. epiphylla* (Schw.) Long should be found also in the northeastern part of the state, since the writer has recently collected this species in southern Arkansas near the Texas border.

Ravenelia roemerianae, sp. nov.

O. Pycnia unknown.

II. Urediniospores intermixed with the teliospores, oval, obovate to obovate-oblong, 13–18×28–37 μ, average for 10 spores 15.4×32.2 μ; walls thin, 1–1.5 μ, slightly thicker above, prominently but sparsely echinulate; spinules very sparse to almost wanting on upper third of spore, upper half golden brown to wine color, lower half paler or almost colorless; germ pores 8, equidistant in two zones of 4 each, one zone in equator, the other between equator and base of spore; paraphyses abundant, intermixed with the spores, clavate to clavate-capitate, 35–50 μ long, average length for 10 paraphyses 44.4 μ, heads 8–13 μ broad, average for 10 heads 10 μ, apex of head thickened about 3 μ, pale fulvous, stipe solid to thin-walled, semi-hyaline.

III. Telia epiphyllous, rarely hypophyllous, scattered, soon naked; subcuticular, blackish, shining, 0.3–1 mm. across, irregularly oval, ruptured cuticle moderately noticeable; teliospore heads chestnut brown, 5–7 cells across, 67–86 μ, average for 10 spores 75.2 μ, verrucose, each spore bearing 6–10 colorless warts about 2 μ high by 3 μ broad; cysts 6–8, flattened and appressed beneath the head, extending from periphery to pedicel, ovoid to oblong-ovate, slow to burst in water, united laterally; pedicel short, colorless, deciduous.

On Mimosaceae. Type collected on *Acacia roemeriana* at San Marcos, Texas, November 1, 1915, by *W. H. Long* (no. 5498). This rust is probably distributed throughout southwestern Texas within the range of its host, but at present is known only from the type locality.

Ravenelia roemerianae is closely related to *R. versatilis*, but differs in its smaller and verrucose teliospore heads and in the fact that it does not form witches' brooms as does *R. versatilis*. Only a few urediniospores of *R. roemerianae* were seen. The urediniospores of both species are very similar in size, shape, color, and in the number and arrangement of the germ pores. These are the only two species of *Ravenelia* so far known which have two rows of germ pores, one in the equator and the other near the base of the spore.

Ravenelia morongiae, sp. nov.

O. Pycnia unknown.

II. Uredinia amphigenous and caulicolous, perennial in tissues of host, often causing early shoots to become swollen and some-

what abortive, but not forming distinct witches' brooms, thickly covering large areas, sometimes confluent or scattered or in circinating groups, oval to irregularly orbicular on leaves, or oblong and often confluent on the branches, subcuticular, early naked, light cinnamon brown, pulverulent, ruptured cuticle inconspicuous; paraphyses very numerous, intermixed with the spores or in separate sori, very variable in shape and size, ranging from clavate to subcapitate or even bladdery, 40–60×12–20 μ, usual length 50 μ, head and stipe about equal in length, heads 12–20×20–25 μ, walls of head very thin, about 1 μ thick, except at apex where the walls are about 3 μ thick, apex pale fulvous to cinnamon brown, strongly colored for 5–7 μ as if thickened, remainder of head semi-hyaline, stipe hyaline, sometimes solid, 2–4 μ thick, 22–30 μ long, many of the paraphyses collapse to a hypha-like shape; urediniospores broadly oval to globose, 14–18×15–20 μ, average for 10 spores 16.5×17.6 μ; walls 1.5–2 μ, fulvous, densely verrucose-spinulose, concolorous, germ pores 8–12, scattered.

III. Telia hypophyllous, small, scattered, sparse, very inconspicuous, irregularly oval, blackish, shining, pulverulent, subcuticular, soon naked, ruptured cuticle inconspicuous; teliospore heads chestnut brown, strongly convex above, 4–6 cells across, 6–12 peripheral cells, 50–70 μ, average for 10 heads 61.7 μ, smooth; cysts few, about as many as peripheral spores of head, closely appressed to under side of head around the stipe, slowly swelling in water to a globular shape and bursting; pedicel very short, hyaline, deciduous.

On Mimosaceae. Type for uredinia collected on *Morongia uncinata* at Austin, Texas, May 23, 1915, by *W. H. Long* (no. 5398). Type for telia collected in same locality and on same host October 29, 1915 (no. 5474, *W. H. Long*).

Although this host is very common and widely distributed, ranging from Virginia to Florida along the Atlantic coast and from South Dakota through Arkansas and Texas to the Gulf of Mexico, this is the first time a species of *Ravenelia* has been reported on it. For 15 years the writer has carefully examined any plants of *Morongia* seen on every field trip, but never with any success until this past year. The rust was found in one of the cemeteries at Austin and was limited to an area about 20 feet in diameter, although the host was widely distributed in that immediate vicinity.

An abundance of uredinia was present on the host in May, but no telia were found. A second collection from the same spot in July by Dr. I. M.

LEWIS still showed only uredinia. In October Dr. LEWIS and the writer again visited the same area and found telia sparingly present. Only an occasional leaf on each plant showed any telia, and then usually only one or two sori to a leaflet. The rust is very inconspicuous, even when the host is thoroughly infected with the uredinial stage, and it is almost impossible to find in the telial stage.

Ravenelia thornberiana, sp. nov.

O. Pycnia unknown.

II. Uredinia amphigenous, caulicolous and fruticolous, usually forming small witches' brooms 3–6 cm. long by 2–4 cm. broad, consisting of a rather dense interwoven mass of abortive branches, petioles, and young pods, thickly covering large areas, often confluent on stems and pods, irregularly orbicular to elliptical or on the branches oblong, very small, 0.2–0.5 mm. in diameter, subcuticular early naked, cinnamon brown, ruptured cuticle noticeable; paraphyses abundant, intermixed with the urediniospores, clavate to subcapitate, 10–13×35–57 μ, heads 10–13×13–17 μ, average for 10 heads 11.6×15.8 μ, apex of head fulvous, lower one-third semi-hyaline, walls 2–3 μ thick, rarely slightly thicker at apex, stipe attenuate, hyaline, 2–4 μ thick by 20–40 μ long, average for 10 stipes 3×31.4 μ; urediniospores obovate, pyriform or oval, 16–18 ×20–27 μ, average for 10 spores 17×23.5 μ, walls 1.5–2 μ thick, sometimes slightly thicker at base, densely and evenly verrucose, cinnamon brown, concolorous, pores 8–12, in two transverse zones of 4–6 pores each, equidistant from the equator.

III. Telia amphigenous and caulicolous, small, 0.2–0.5 mm. in diameter, irregularly oval, scattered, or often confluent on the petioles and stems, subcuticular, chestnut brown, ruptured cuticle noticeable; teliospore heads chestnut brown, 70–90 μ in diameter, average for 10 heads 80 μ, 4 or 5 spores across, 8–14 marginal spores, smooth; paraphyses present, stipe often not attenuate and solid, otherwise as in the uredinia; cysts delicate, numerous beneath entire head, in two irregular rows around stipe, subappressed, easily swelling and bursting in water, becoming pendent and subglobose in water; pedicel short, hyaline, deciduous.

On Mimosaceae. Type for uredinia collected on *Acacia constricta paucispina* at El Paso, Texas, August 7, 1915, by *W. H. Long* (no. 5505). Type for telia collected in same locality and on same host December 20, 1915 (no.

5506, *W. H. Long*); also collected at Tucson, Arizona, on *Acacia constricta paucispina* (nos. 5507 and 5508, *W. H. Long*).

On a recent trip to Tucson, the writer's attention was called by Professor THORNBER, of the University of Arizona, to a species of *Ravenelia* on *Acacia constricta paucispina* which formed small witches' brooms. The host was growing on the grounds of the University of Arizona immediately adjacent to a tree of *Acacia greggii* which has heavily infected with *R. versatilis*. The close proximity of the two host trees and the fact that both bore witches' brooms suggested the possibility of the *Ravenelia* on *Acacia constricta paucispina* being *R. versatilis*. However, a microscopic examination of the rust revealed marked differences in the urediniospores which easily separated it from *R. versatilis*. On this trip, the writer revisited a locality at El Paso, Texas, where he had collected a *Ravenelia* in August 1915 on an unidentified host. This host proved to be *Acacia constricta paucispina*, and the *Ravenelia* on it was identical in every way with that collected on the same host at Tucson, Arizona. The specimens of *R. thornberiana* collected at Tucson had only fresh telia intermixed with old and weathered uredinia. The collection of this rust made by the writer at El Paso in August 1915 consisted of fine uredinial material, while that made from the same trees at El Paso in December 1915 was good telial material. For this reason, the material collected at El Paso is made the type for the species.

The number of species of *Ravenelia* previously described whose uredinia or telia cause pronounced witches' brooms is limited to 4 species, namely, *R. versatilis* on *Acacia greggii*, *R. fragrans* on *Mimosa fragrans*, both American species; and two African species, *R. volkensii* P. Henn. on *Acacia* sp. (only the teliospores of which are known), and *R. natalensis* Syd. and Evans on *Acacia hirtella* (which has aecia as well as uredinia and telia). Of these 4 species, *R. versatilis* is the only one which has urediniospores with two rows of germ pores, but this species has one row at the equator and the other near the base of the spore, while *R. thornberiana* has its two rows of germ pores equidistant from the equator. The lower halves of the urediniospores of *R. versatilis* are hyaline, while the urediniospores of *R. thornberiana* have walls uniformly colored.

There are only two described species of *Ravenelia* with germ pores in two rows equidistant from the equator, namely, *R. siliquae* Long on *Vachellia farnesiana* and *R. acaciae-pennatulae* Dietel on *Acacia pennatula*. *R. thornberiana* differs from *R. siliquae* in having very small uredinia and in the shape and size of its urediniospores. It differs from *R. acaciae-pennatulae* in having smooth teliospore heads.

Ravenelia reticulatae, sp. nov.

O. Pycnia unknown.

II. Uredinia hypophyllous, scattered, punctiform to elliptical, very small, 0.25–0.5 mm. across, subcuticular, tardily naked,

light cinnamon brown in herbarium material, ruptured cuticle noticeable; paraphyses present but not abundant, intermixed with the urediniospores, clavate to spoon-shaped, 10–13×40–70 μ, average for 10 paraphyses 12×47 μ, wall thickened above, 5–8 μ, heads fulvous, stipe hyaline, solid; urediniospores globoid, 16×16–19 μ, average for 10 spores 16×16.9 μ; walls pale fulvous, 1–1.5 μ thick, concolorous, densely verruculose, pores 6–10, scattered.

III. Telia amphigenous, scattered, large compared to uredinia, oval to orbicular, 0.5–1.5 mm. across, subcuticular, early naked, ruptured cuticle noticeable, chestnut brown; paraphyses few; teliospore heads light chestnut brown, 65–105 μ in diameter, average for 10 heads 82.4 μ, 7–9 cells across, 15–24 peripheral cells, each spore 14–16 μ across, smooth; cysts appressed to underside of head around the stipe, about one to each peripheral teliospore, swelling rather slowly and bursting in water, apparently not coherent with each other, not continuous with stipe; stipe short, hyaline, deciduous.

On Mimosaceae. Type collected on *Calliandra reticulata* at Divide, Lower Trail, Rincon Mountains, Arizona, September 12, 1909, by *J. C. Blumer*, at an altitude of 7,200 feet (no. 5510, *W. H. Long*). This species of *Ravenelia* was found by the writer in the herbarium of the University of Arizona on "*Calliandra reticulata*, plants of the Rincon Mountains, Arizona, no. 3341, *J. C. Blumer* collection."

Including the species above described, there are now 7 species of *Ravenelia* known to occur on *Calliandra*. Five of these occur in South America, namely, (1) *R. lagerheimiana* Dietel on *Calliandra* sp., (2) *R. echinata* Lagh. and Dietel on *Calliandra* sp., (3) *R. pazschkeana* Dietel on *Calliandra* sp., (4) *R. dieteliana* P. Henn. on *Calliandra microcephala*, and (5) *R. affinis* Syd. on *Calliandra turbinata*. One species, *Ravenelia mexicana* Tranz on *Calliandra grandiflora*, is found in Mexico; while the species described here, *R. reticulatae* on *Calliandra reticulata*, is the only one known from the United States on this host genus.

Ravenelia dieteliana and *R. affinis* are the only species previously described on *Calliandra* which have smooth teliospore heads. Both of these species are subepidermal and have urediniospores with germ pores (4) situated in the equator of the spores, while *R. reticulatae* is subcuticular and has 6–10 germ pores which are scattered. *R. reticulatae* also has other material differences which separate it from either of the two species having smooth teliospore heads.

R. reticulatae is closely related to *R. texensis* on *Acuan jamesii*, but differs from this species in having an entirely different host and in having smaller and thinner-walled urediniospores, while practically all of its telial characters are different.

Ravenelia annulata, sp. nov.

O. Pycnia unknown.

II. Uredinia epiphyllous, very sparingly present, elliptic to irregularly oval, small, less than 0.5 mm. in diameter, subepidermal, tardily naked, ruptured, epidermis very noticeable; paraphyses sparingly present, clavate to subcylindrical, 8–16×36–70 μ, apex thickened 5–7 μ, light chestnut brown, stipe subhyaline, walls rather thick; urediniospores ovate to ovate-fusiform, asymmetrical, usually prominently acuminate, 17–23×27–37 μ, average for 20 spores 19.5×31.4 μ; walls 2 μ thick, cinnamon brown, sparsely but prominently echinulate, with a broad hyaline band or ring around the equator 7–10 μ wide, often abruptly narrowed into a short subcylindrical base, which is hyaline for 4–7 μ, occasionally with remnants of pedicel attached, the walls of which are hyaline and minutely verruculose; germ pores 6, small, in hyaline equatorial belt.

III. Telia epiphyllous, not seated on pallid spots, small, narrowly elliptical to irregularly oval, 0.125–0.5×0.5–1.0 μ, subepidermal, light chestnut brown, tardily naked, ruptured epidermis very conspicuous; paraphyses numerous, inconspicuous, surrounding the telia, same in shape, size, and coloring as those found in the uredinia, apparently no paraphyses situated among the teliospores; teliospore heads light chestnut brown, very irregular in size and shape, irregularly oval, flattened, smooth, 50–73×53–87 μ, average for 10 heads 62.0×72 μ, 4–7 cells across, 8–16 cells around margin of head, 12–34 spores or cells in each head; cysts hyaline, few, about one to each peripheral spore, appressed, extending from pedicel to periphery, united laterally, easily bursting in water; pedicel colorless, short, deciduous.

On Mimosaceae. Type collected on *Lysiloma latisiliqua* at Miami, Florida, March 12, 1914, by W. *H. Long* (no. 4623).

This *Ravenelia* is rather common on small bushes (4–10 feet high) of this host, especially along the railroad tracks traversing the hammocks near Miami.

The strongly acuminate urediniospores with their broad, hyaline, equatorial zones and cylindrical hyaline bases make *R. annulata* a very unique species. It is closely related to *R. lysilomae,* but differs from this species in its smaller and differently-shaped sori, in its acuminate urediniospores with

hyaline cylindrical bases and 6 germ pores, and in its smaller and very irregularly-shaped teliospore heads with only about one-half as many spores to each head as *R. lysilomae*.

The writer has carefully examined mounts made from the type collection of *R. lysilomae*, and found some 30–40 urediniospores intermixed with the teliospores. None of the urediniospores seen was acuminate, all had only 4 germ pores which were rather large and prominent. The teliospore heads measured 60–100×65–120 μ in diameter, average for 10 heads 86×92 μ, 7–10 cells across, 12–20 peripheral cells and 26–50 cells to a head.

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A STUDY OF THE LIFE HISTORY OF TRILLIUM CERNUUM L.

MARGARET HEATLEY

(WITH PLATE XXVII)

The following study of the origin and development of the female gametophyte of *Trillium cernuum* has been made with a view to a more detailed cytological and embryological study of *T. cernuum* and *T. grandiflorum* and their possible hybrids. It was undertaken at the suggestion of Dr. FERGUSON, to whom I am greatly indebted for helpful discussion and criticism.

ATKINSON[1] has given a careful description of microsporogenesis in *T. grandiflorum*. ERNST[2] has published a very brief and as yet uncompleted account of chromosome reduction, development of the embryo sac, and fertilization in *T. grandiflorum*. GRÉGOIRE and WYGAERTS[3] have used *T. cernuum* and *T. grandiflorum* as a basis for detailed studies on the reconstruction of the nucleus and the formation of chromosomes. As yet, however, no account of the life history of *T. cernuum* has been given.

Trillium cernuum is a native of Massachusetts and grows in sufficient abundance in the vicinity of Wellesley College to furnish plenty of material for investigation. The work of collecting was done in 1911 and 1912. From the first week in April until the end of May, material was gathered once or twice each day. The fixing was generally done in the field. The most satisfactory fixing agent was a weak solution of Flemming's chromo-acetic-osmic fluid. Of the several stains tried, Haidenhain's iron-alum-hematoxylin and Flemming's triple stain gave the best results.

[1] ATKINSON, G. F., Studies on reduction in plants. BOT. GAZ. **28**:1–24. *pls. 3–6*. 1899.

[2] ERNST, A., Chromosomenreduction, Entwickelung des Embryosackes, und Befruchtung bei *Paris quadrifolia* und *Trillium grandiflorum*. Flora **91**:1–36. *pls. 1–6*. 1902.

[3] GRÉGOIRE, VICTOR, and WYGAERTS, A., La reconstitution du noyau et la formation des chromosomes dans les cinèse somatiques. La Cellule **21**:7–76. *pls. 2*. 1904.

By the end of September the flower buds are well formed and the parts of the ovules are clearly differentiated (fig. 1). An archesporial cell immediately below the epidermis has divided and given rise to a primary parietal and a megaspore mother cell (fig. 2). In some ovules the primary parietal cell remains undivided (fig. 2), while in others it divides longitudinally (fig. 1). ERNST (*loc. cit.*) finds no formation of primary parietal tissue in *T. grandiflorum*.

During the winter, the megaspore mother cell of *T. cernuum* is in a resting state and is easily distinguishable from the surrounding cells because of its larger size and its larger and more deeply staining nucleus (figs. 1, 2). If meiosis is accepted as the criterion for spore formation, the fact that this cell later undergoes the reduction divisions proves it to be a megaspore mother cell. The physiologically analogous cell of *T. grandiflorum* is called by ERNST (*loc. cit.*) the embryo sac mother cell. He says: "Die Embryosackmutterzelle differenzirt sich in der subepidermalen Zellschicht unmittelbar unten dem Scheitel des Nucellus." Since, as in *T. cernuum*, this cell does not give rise directly to the embryo sac, it cannot be the true embryo sac mother cell, and this terminology should be discarded.

With the resumption of growth in late March or early April, active cell division may be observed in all parts of the flower. The resting reticulum of the megaspore mother cell gradually loses its netlike structure and resolves itself into a dense synaptic mass (fig. 3). Later stages show the chromatin threads to have thickened, shortened, and segmented transversely into distinct chromosomes (fig. 4). After a second contraction of the nuclear material (fig. 5) the separate chromosomes soon become arranged at the nuclear plate, while delicate spindle fibers can be distinguished in the cytoplasm (fig. 6).

Anaphase and telophase are quickly passed through, as ERNST (*loc. cit.*) has reported for *T. grandiflorum*, and each of the resulting daughter nuclei becomes invested with a delicate nuclear membrane. The chromosomes of each nucleus seem to fuse end to end to form a long, thick, loosely wound band, but there is no evidence from the material studied that they completely lose their identity at this time and form a reticulum. During this short resting

period, the cell plate gradually becomes heavier and extends across the entire cell as a dividing wall (fig. 7). Every step of this division clearly indicates that it is the heterotypic phase of meiosis.

Although the daughter cells are at first apparently similar in all respects, the chalazal one gradually shows signs of greater vitality, and by more rapid growth encroaches upon the micropylar cell (figs. 8–13). In no case have I found the outer cell giving evidence of being the more vigorous. It may disintegrate immediately (fig. 8); it may pass through one or more phases of the homotypic division (figs. 9–11); or it may even complete meiosis before disorganizing (figs. 12–14). A study of many ovules shows that no cell wall is ever laid down, and that even though the spores may be formed they never become functional, but disintegrate early (fig. 15).

At the completion of the homotypic division in the chalazal cell, no cell wall is formed, and the resulting 2 nuclei undergo a period of rest lasting 2 or 3 days. The cell increases rapidly in size and becomes very vacuolate (fig. 16). The formation of a large, central vacuole soon forces the 2 nuclei to opposite ends of the cell. It is very evident that this structure is a young embryo sac, and thus the female gametophyte is derived from 2 megaspores. ERNST states that 2 megaspores enter into the formation of the embryo sac of *T. grandiflorum*. COULTER and CHAMBERLAIN[4] describe an axial row of 4 megaspores for *Trillium* and report that in *T. recurvatum* the embryo sac is derived from the chalazal megaspore. A study of CHAMBERLAIN'S figures for *T. recurvatum* reveals striking resemblances to those for *T. grandiflorum* and *T. cernuum*. As in the last two named species, there is an axial row of 2 binucleate cells which have resulted from the "second division of the nucleus of the mother cell." No sketch of the 4-celled axial row mentioned in his text is given. The next stage illustrated is that of the young 2-celled embryo sac capped at the micropylar end by a dense, contracted mass, "the remains of the other 3 megaspores." Fig. 15 of this paper shows a very similar embryo sac, but an examination of the preceding stages illustrated makes it clear that the

[4] COULTER, J. M., and CHAMBERLAIN, C. J., Morphology of the angiosperms. Chicago. 1901.

disintegrating masses of tissue represent the remains of only 2 megaspores. Even though it may be true that the number of cells in the axial row varies in closely related species of the same genus, this does not seem to be the case for the 3 species of *Trillium* under discussion. The close resemblance of the series of figures given for each of the 3 species and the fact that CHAMBERLAIN does not figure a 4-celled axial row make it highly probable that *T. recurvatum*, like *T. grandiflorum* and *T. cernuum*, has an axial row of 2 binucleate cells, and that the first 2 cells of its embryo sac represent 2 megaspores. During a summer session which I spent at the University of Chicago in 1912, Dr. CHAMBERLAIN very kindly examined my slides covering these stages and agreed with this interpretation.

After a period of growth of the young embryo sac, the 2 nuclei divide rapidly to form a 4-nucleate, and then an 8-nucleate, embryo sac (figs. 17–19). These phenomena and those attending the maturation of the embryo sac agree so closely with the account already given by ERNST for *T. grandiflorum* as to make further comment on them unnecessary.

From the foregoing account it may be seen that *T. grandiflorum* and *T. cernuum*, the 2 species to be used in the work of hybridizing, agree in all important respects regarding the origin and the development of the embryo sac. The chief points of difference in the two accounts are as follows: (1) one row of primary parietal tissue is formed in the ovules of *T. cernuum*, while in *T. grandiflorum* primary parietal tissue is entirely wanting; (2) in *T. cernuum* the 2 nuclei resulting from the heterotypic division do not form resting reticula.

WELLESLEY, MASS.

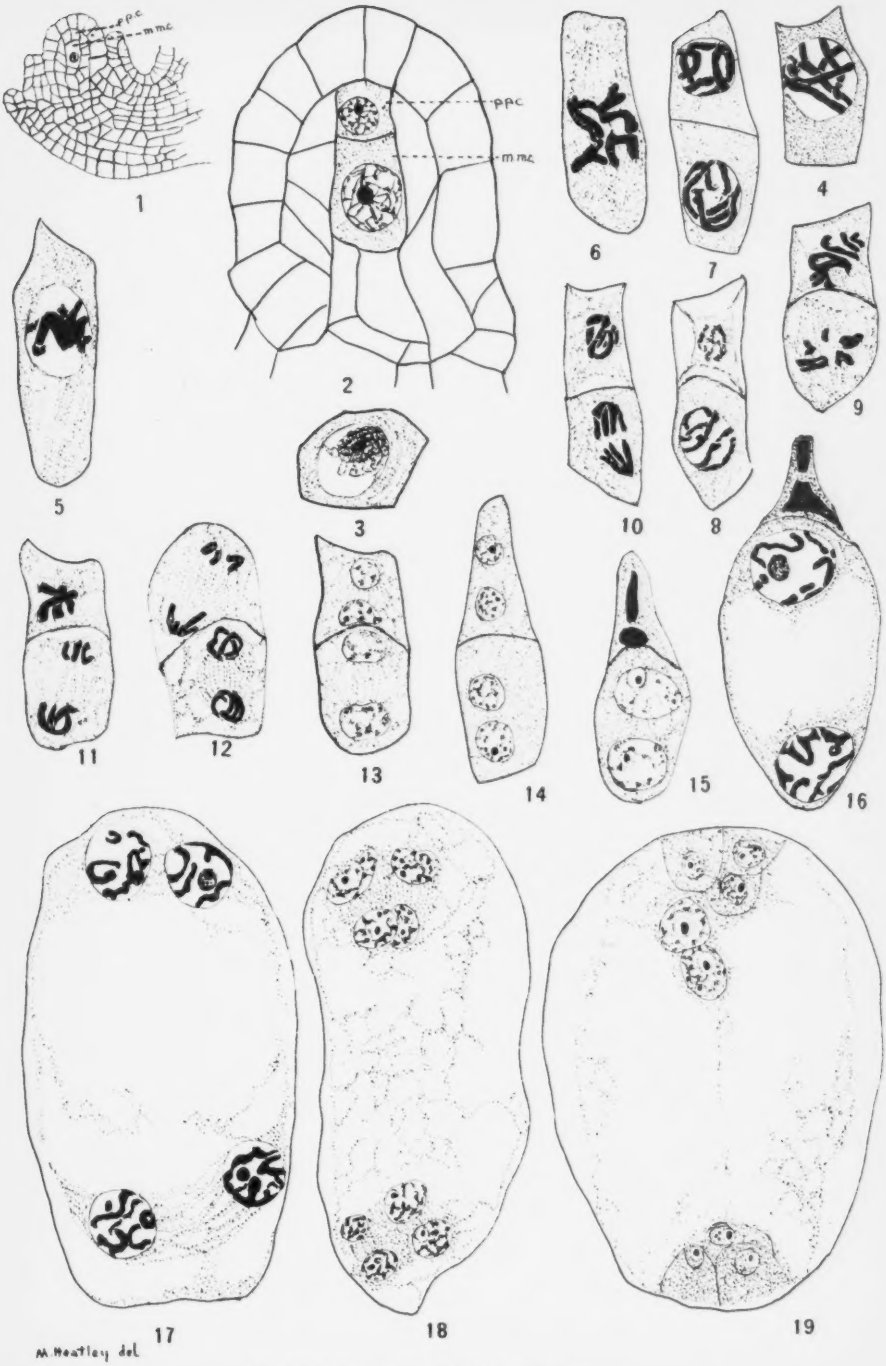
EXPLANATION OF PLATE XXVII

An Abbé camera lucida was used for all of the drawings. The figures are oriented with the micropylar end toward the upper edge of the page. The abbreviations used in labeling the drawings are as follows: *m.m.c.*, megaspore mother cell; *p.p.c.*, primary parietal cell.

FIG. 1.—Longitudinal section of a young ovule; ×73.

FIG. 2.—Same as fig. 1; ×430.

FIG. 3.—Megaspore mother cell in synapsis; ×430.



HEATLEY on TRILLIUM CERNUUM

FIG. 4.—Post-synaptic stage of megaspore mother cell; ×430.

FIG. 5.—Second contraction in megaspore mother cell; ×430.

FIG. 6.—Megaspore mother cell in anaphase of heterotypic division; ×430.

FIG. 7.—The daughter nuclei separated by a heavy cell wall and giving evidence of formation of continuous spirems; ×430.

FIG. 8.—Continuous spirem in chalazal daughter nucleus; early disintegration of micropylar daughter nucleus; ×430.

FIGS. 9–12.—Micropylar daughter cell unable to organize a spindle; chalazal daughter cell in various phases of the homotypic division; ×430.

FIGS. 13–14.—Homotypic division completed in both daughter cells, resulting in axial row of 2 cells, each containing 2 megaspores; ×430.

FIG. 15.—Outer 2 megaspores disintegrated; ×430.

FIG. 16.—Chalazal daughter cell with its 2 megaspores functioning directly as a 2-nucleate embryo sac; ×430.

FIG. 17.—Four-nucleate embryo sac; ×430.

FIG. 18.—Eight-nucleate embryo sac; ×430.

FIG. 19.—Mature 8-nucleate embryo sac with egg apparatus, antipodals, and polars differentiated; ×430.

THE SIGNIFICANCE OF COLOR CHANGES IN OXIDASE REAGENTS

G. B. Reed

Our knowledge of the oxidases has been derived almost entirely from the study of their action upon compounds which change color on oxidation. It is customary to employ for this purpose compounds which do not oxidize spontaneously (or do so very slowly) when exposed to the air in dilute solutions, but which when brought into contact with living tissues (or extracts of tissues) exhibit a change of color.

The formation of such colored compounds as a result of oxidase action has afforded a ready method of determining the distribution of these ferments. The behavior of the various indicators when placed in contact with different tissues has also led to the conclusion that the oxidases may be divided into several more or less definite classes.

The rate of oxidase action and the relative efficiency of different preparations of oxidases have also been determined by measuring the intensity of the color produced in solutions of such indicators.[1]

Valuable as these methods have been, they have given no indication of the amount of oxidation which has taken place. Thus, when an oxidase causes a change of color in one of these reagents we have no idea of the amount of oxidation which this reaction represents. Moreover, it often has been assumed that the appearance of a definite color in any of these reactions, acted upon by the oxidases, represents similar amounts of oxidation. For example, an oxidase capable of bringing about sufficient oxidation to give a distinct blue color in a solution of gum guaiac has been considered about as efficient as one capable of producing enough purpurogallin to give a distinct yellow color in a solution of pyrogallol.

Inasmuch as the greater part of the results obtained by workers on oxidase reactions depend upon these color changes, it is important

[1] The various methods employed in colorimetric determinations of the rate of oxidase action have recently been reviewed by Foa, Biochem. Zeit. 2:382–399. 1908; and also by Bunzell, Bull. no. 238. Bur. Pl. Ind., Washington. 1911.

to have a clear conception of their quantitative as well as of their qualitative meaning. The following experiments present such quantitative values.

Solutions of a number of the oxidase reagents in most common use were made up in equivalent concentrations, 0.1 M in water (in the case of aloin and alpha napthol in 50 per cent alcohol, as they are only slightly soluble in water). As gum guaiac consists of a number of compounds in unknown proportions, a 2 per cent solution of the resin in 50 per cent alcohol was taken.

Two beakers, each containing 100 cc. of one of these solutions, were placed in a uniform light in such a position that the colors of the solutions could be accurately compared. A standard potassium permanganate solution[2] was then added to one beaker in sufficient amount to cause a definite change in color due to oxidation, as compared with the beaker to which no addition was made.[3]

Table I indicates the amount of permanganate required to produce the first perceptible change of color in the several reagents tested. The last column of the table also gives the amount of oxygen used in the oxidation as calculated from the amount of permanganate required.

TABLE I

Solution: 100 cc. 0.1 M	Amount (cc.) of standard $KMnO_4$ required to produce a definite color	Gram atoms of oxygen required to produce a definite color
Aloin	1	1.2×10^{-6}
Alpha napthol	2	2.5×10^{-6}
Alpha napthol and paraphenylene diamine	2	2.5×10^{-6}
Benzidine	3	3.7×10^{-6}
Dimethyl paraphenylene diamine	0.5	5.1×10^{-6}
Gum guaiac*	trace	trace
Hydrochinone	10	1.2×10^{-5}
Paraphenylene diamine	1	1.2×10^{-6}
Paracresol	1	1.2×10^{-6}
Pyrogallol	9	1.1×10^{-5}

* A 2 per cent solution was used, as the molecular weight is not known.

[2] Of this solution 80 cc. was exactly sufficient to oxidize 10 cc. of 0.1 M oxalic acid.

[3] Since in the oxidation of these reagents the potassium permanganate is reduced to a colorless condition, its color can appear only after a sufficient amount is added to oxidize all of the reagent. Since this condition is not reached, the permanganate produces no color to obscure the color of the compounds produced by the oxidation.

Similar results were obtained in the oxidation of the naturally occurring chromogens, although they cannot be stated in as definite a form. Equal amounts (25 gm. of fresh material) of tissue of apple, of potato, and of the stems of *Vicia Faba* were each crushed in 100 cc. of water and filtered rapidly. Enough of the standard permanganate was then added to each solution to give the first appearance of the chromogen color. Table II indicates the amounts of permanganate required and the amounts of oxygen which they represent.

TABLE II

Water extract; 100 cc.	Amount (cc.) of standard $KMnO_4$ required to produce chromogen color	Gram atoms of oxygen required to produce chromogen color
Potato	9	1.1×10^{-5}
Apple	6	7.5×10^{-6}
Vicia Faba stems	4	5.0×10^{-6}

These results indicate that the amount of oxidation necessary to produce the colored appearance in either the ordinary oxidase reagents or in the plant chromogens is exceedingly small. This, however, does not indicate that the oxidases are capable of producing only a small amount of reaction, for after the color appears the oxidation may continue without necessarily changing the color.

These observations also clearly indicate that the amount of oxidation necessary to produce a color in the various reagents varies over a wide range. But by this very simple method the different reagents may be calibrated so that the effects of the oxidases may be measured, and the oxidation necessary to produce a change of color in the presence of oxidases may be expressed in grams of oxygen required.

LABORATORY OF PLANT PHYSIOLOGY
HARVARD UNIVERSITY

BRIEFER ARTICLES

COUNT SOLMS-LAUBACH[1]

(WITH PORTRAIT)

By the death of HERMANN, Graf zu SOLMS-LAUBACH, on November 24, 1915, Germany has lost the most distinguished of her botanists and the world of science one of its most impressive figures. Count SOLMS was born on December 23, 1842, and had thus nearly completed his seventy-third year. He came of one of the most ancient of German families, who were sovereign in their own domains down to the year 1806. He himself devoted his life wholly to science, holding the professorship of botany first at Göttingen and afterward at Strassburg. He resigned the latter post a few years ago, but continued to live in the town, surrounded by his university friends.

His work extended to every department of botany. Beginning with an important series of researches on parasitic phanerogams, he subsequently monographed several natural orders, including the screw pines. His interest in the morphology of flowering plants continued in later years; in 1900 he described the remarkable crucifer *Capsella Hegeri*, with indehiscent fruits, regarding it as a mutant of the common *C. Bursa-pastoris*. He was always interested in variation, and carried out important investigations on the history of cultivated plants, such as the fig, the pawpaw, wheat, tulips, and strawberries. In embryology

[1] From a biographical sketch published in *Nature*, January 13, 1916.

he showed that in certain monocotyledons the growing point of the embryo is terminal, as in dicotyledons.

In addition to the flowering plants, his systematic researches extended to every class of cryptogams. One of his most remarkable works in this field is his monograph of the Acetabulariaceae, a family of calcareous algae with an ancient fossil history. This was published in 1895 in the *Transactions of the Linnean Society*, and was his only paper written in English. His book on the *Principles of Plant Geography* (1905) treats in an original manner of the leading conceptions in this great subject.

Perhaps the most important of all his work was that on fossil botany. His *Einleitung in die Paläophytologie*, published in 1887 and translated for the Oxford Press in 1892, was of the utmost importance in bringing home to botanists the value and significance of the geological record as affecting plants. Among his special papers may be mentioned his brilliant work on the Isle of Wight fossil *Bennettites Gibsonianus* (1890; translated 1891), the type of the mesozoic cycadophytes; on the Cycadofilices *Protopitys*, *Medullosa*, etc.; on plants of the Devonian and Lower Carboniferous of Germany; and on *Psaronius*. In a quite recent paper on the last-mentioned group he elucidated, for the first time, the true nature of the root zone. The remarkable recent progress of paleobotany is in a great degree due to his researches.

Count SOLMS became a foreign member of the Linnean Society in 1887, of the Royal Society in 1902, and of the Geological Society in 1906. He received the gold medal of the Linnean Society in 1911, and was made a Sc.D of the University of Cambridge at the Darwin Celebration in 1909. He was a striking and original personality, of rare intellectual power, and a born leader of men.—D. H. SCOTT, *Royal College of Science, London.*

CURRENT LITERATURE

NOTES FOR STUDENTS

Age changes in leaves.—An interesting and important paper by BENEDICT[1] is an attempt to answer the question whether general progressive age changes occur during the vegetative life of a woody perennial, and constitutes, so far as the reviewer's knowledge goes, the first positive evidence based on exact observation for an affirmative answer to the question. The author approaches his subject with a brief résumé of the physiological and morphological age changes in animals, pointing out that much more attention has been paid to the phenomena of senescence in animals than in plants, there being as regards plants practically no really conclusive data at hand. He emphasizes both the scientific and the practical importance of the question whether plants actually grow old, and notes that in view of the great differences in length of life in different animal species the very great length of life attained by certain trees does not constitute any real answer to the question.

As the chief material for his own study of senescence in plants the author has chosen the leaves of the wild grape (*Vitis vulpina* L.) for various excellent reasons noted in the paper, and his observations concern primarily the size of the aggregations of photosynthetically active cells, the vein islets in the meshes of the network of veinlets, or in other words the size of these meshes. Briefly stated, the chief results of the paper are these: The size of the vein islets is essentially the same in different regions of the same leaf and in leaves of different size and thickness from plants of the same or nearly the same age, and differs but slightly with ordinary differences of light and shade. A comparison of minimum and maximum areas of the vein islets in different leaves of the same plant also shows much less variation than the areas and thicknesses of the leaves themselves. All these facts indicate that the size of the vein islets is governed by some internal characteristic of the plant as a whole, or more specifically of the meristematic tissue. The ground being thus cleared, the next step is the comparison of the size of the vein islets in the leaves of plants of different ages, age being determined by the number of rings in the main trunk or in some extreme cases by the size of the trunk. The very extensive series of measurements show beyond question that the size of the vein islets is greatest in the youngest plants and undergoes a progressive decrease with advancing age. This difference in size holds good for immature as well as for mature leaves, and also for cuttings from plants of different age as well as for the plants

[1] BENEDICT, H. M., Senile changes in leaves of *Vitis vulpina* L. and certain other plants. Cornell Univ. Agric. Exp. Sta. Memoir no. 7. pp. 281–370. 1915.

themselves; that is, vegetative propagation does not bring about rejuvenescence in this respect. The rate of decrease in the size of the vein islets is highest in the earlier years of life of the vine and decreases in later years, and when plotted as a curve shows a decrease in steepness and approach to horizontal with advancing age. The identity of type of this curve with the curve of decrease in pulse rate in human beings and the decrease in rate of growth in guinea-pigs is strikingly shown by graphic comparison.

These observations on *Vitis vulpina* are supplemented by less complete data on other woody perennials: *V. bicolor*, *Tecoma radicans*, and a number of trees, including species of *Salix*, *Castanea*, *Quercus*, *Tilia*, *Ulmus*, *Carya*, *Acer*, *Platanus*, and *Fraxinus*, all of which lead to the same conclusions, as do also observations on several pedigreed varieties of grape which have been propagated by cuttings for known different lengths of time. Other age changes determined in the leaves of *Vitis* are decrease in rate of CO_2 production, decrease in imbibition of water by powdered leaves, decrease in acidity, increase in number and decrease in size of stomata, and probably a decrease in size of palisade cells and an increase in the proportion of cytoplasm to nucleus.

In the discussion particular attention is called to the significance of these facts in connection with the question of the deterioration and running out of cultivated fruits and other plants propagated by vegetative means, and then, after criticism of some of the various theories of senescence based primarily on zoological data, BENEDICT concludes that a decrease in permeability of the cells will best account for the observed facts. With this decrease in permeability of the photosynthetic cells, diffusion of water and salts through them is retarded, and the results obtained by various investigators indicate that lack of water in the cells of the leaf stimulates the production of veinlets. He points out, however, that this decrease in permeability with advancing age is itself dependent upon the properties of colloids, and that the fundamental factors of senescence are to be found in the properties of the protoplasmic colloids.

The reviewer welcomes this paper, not only for its scientific and practical significance, but also as affording in general confirmatory evidence for his own conclusions based on an experimental study of certain simple animals, and for certain suggestions concerning senescence and rejuvenescence in plants. It seems worth while to point out, however, that changes in the meristematic tissue, such as BENEDICT has discovered, are not the only age changes in the plant. The cells which differentiate from the meristematic tissue undoubtedly grow old much more rapidly than the meristematic tissue. The changes in the meristematic tissue of *Vitis* which determine the decrease in size of the vein islets must be at most only the earliest stages of senescence. Differentiation in any appreciable degree is not yet present in this tissue, but that is no reason why it may not become an important factor in more advanced stages of senescence. Protoplasmic differentiation is undoubtedly of less significance in this respect than in animals, where its relation to senescence is evident.

It may also be pointed out that a period of senescence which seems when viewed superficially to be uniformly progressive may be made up of many alternating periods or cycles. There is evidence that in at least many cases the cell undergoes changes in the direction of senescence between divisions, and in the direction of rejuvenescence at division. It may be that the very slow aging of the meristematic tissues of plants, as compared with that of cells which cease to divide, is associated with the frequent occurrence of division. Likewise, the localization and outgrowth of a new growing tip, even in meristematic tissue, must involve, at least often, a slight rejuvenescence of the cells concerned. Thus the progressive senescence of the meristematic tissue in such a case as that of *Vitis* may consist of innumerable periods of alternate slight senescence or retardation and rejuvenescence or acceleration, in which the latter does not quite balance the former. In many of the lower plants, as in certain of the lower animals, such changes apparently do balance each other, at least under some conditions, and vegetative or agamic reproduction or propagation may be continued indefinitely. In general, the evidence seems to indicate that this balance is more complete in the simpler organisms, and that rejuvenescence becomes more and more limited to gametic reproduction as evolution advances.

BENEDICT finds that the rate of decrease in size of the vein islets becomes lower with advancing age in *Vitis*. This suggests the possibility that sooner or later a balance between the shorter periods of senescence and rejuvenescence may be reached, and if such a possibility is ever realized the period of "maturity" may continue indefinitely.

BENEDICT is inclined to minimize the importance of the accumulation of relatively inactive components in the protoplasm as a factor in senescence and to lay chief stress on decrease in permeability. While decrease in permeability is undoubtedly an important factor in senescence, the reviewer has pointed out elsewhere that such a change is merely the surface expression of changes in the colloids or in the protoplasmic substratum, and that similar changes on other limiting surfaces or throughout the substratum may determine differentiation, accumulation of structural substance, and decrease in metabolic rate. In short, decrease in permeability seems to be merely one expression of the great variety of changes concerned in bringing about the decrease in metabolic rate characteristic of senescence. Moreover, it was pointed out above that the changes with which BENEDICT is concerned can be only the earliest stages of senescence in the meristematic tissues. Decrease in permeability may very possibly be one of the chief expressions of these early changes, but certainly in later stages various other factors play important parts.

On the basis of BENEDICT'S conclusions, the changes in permeability of the photosynthetic cells in the leaf must not only interfere with diffusion from cell to cell, but also must decrease metabolic activity within each cell. This

being the case, the question must at least be raised whether the demand for water and nutrients is greater or less in the older than in the younger vein islets. It seems not impossible that the decreasing metabolic activity with advancing age in the vascular tissues themselves may be a factor in determining the increase in the veinlets. The reviewer has shown that the spatial relations of successively arising parts may vary directly with the metabolic rate, and it is perhaps allowable to suggest that in this case the more frequent branching of the veinlets in the older leaves may be to some extent associated with a lower metabolic rate in each new branch, and consequently a lower limit of distance within which it inhibits the development of new veinlets.

In conclusion, it must be noted that BENEDICT's use of the terms "senile" and "senility" is at least unusual. These terms are commonly used only with reference to the extreme stage of senescence preceding death in man and the higher animals, where actual atrophy, degeneration, and necrosis of cells occur, but BENEDICT speaks of senile changes occurring in the early stages of development. To substitute "senile" and "senility" for "aging" and "senescence" is simply to give the former terms a new meaning. To speak of meristematic tissue or of a plant in "vigorous maturity" as senile is to a zoologist or animal physiologist little less than a contradiction in terms. Moreover, the increase in vascular tissue in the leaf with advancing age of the plant is scarcely comparable to the replacement of atrophied organs by connective tissue in man and the higher animals, but resembles rather the increase in stable morphological structure which occurs during development in animals. Criticism of such points, however, does not detract from the interest and significance of BENEDICT's evidence for the occurrence of a gradual, progressive change, slight, but apparently in the direction of senescence, in the meristematic tissues during vegetative life.—C. M. CHILD.

Cecidiology.—American botanists will be interested in a posthumous paper on American insect galls by THOMPSON.[2] In part I, the galls are classified under the generic names of the host plants, with subordinate grouping based on the host plant. The descriptions are very brief, in most cases restricted to a single line, but give the specific names of the host plants and statements as to anatomy. This first part will prove very useful to botanists. Part II groups the galls with reference to the insects causing them and gives a list of host plants for each. This part also includes a bibliography and a lengthy supplemental list which includes a few fungus galls. The illustrations are good and the entire publication will prove very helpful.

American botanists will also be interested in a paper by STEWART[3] on the anatomy of *Gymnosporangium* galls. This paper is summarized as follows:

[2] THOMPSON, M. T., An illustrated catalogue of American insect galls. pp. 66. *pls. 21.* 1915. Edited by Dr. E. P. FELT.

[3] STEWART, ALBAN, An anatomical study of *Gymnosporangium* galls. Amer. Jour. Bot. 2:402–417. 1915.

"*Gymnosporangium juniperi-virginianae* and *G. globosum* cause the formation of large galls on the younger branches of *Juniperus virginiana*. The galls arise from the axils of the leaves and are evidently transformed axillary buds. Young galls have two distinct fibrovascular systems, one of which is a leaf trace bundle, and the other a stem. The more or less modified stem which enters the base of the older galls gradually breaks up and radiates outward, deeper in the gall tissue. Leaf tissue is also involved in gall formation, and remains of it are usually to be found adhering to the older galls. Normal stems sometimes appear to have grown out from the surface of the older galls. Accessory stem structures occur, which probably originate by a branching of the main stem in the gall. Broad, raylike masses of parenchyma, surrounded by tracheids, are of rather common occurrence. Irregularly twisted masses of fibrovascular tissue occur which are similar in many respects to like structures in traumatic wood. Cells which are transitional between parenchyma and tracheids are quite abundant. The irregularly running bundles in the gall are composed largely of scalariform tracheids."

Another very interesting contribution to our American literature is by PING[4] on the well known and very conspicuous round gall of the golden rod. This paper is more entomological than botanical, but contains much that is interesting to the botanist. The author describes the gall which is restricted to *Solidago canadensis* and caused by the larva of *Eurosta solidaginis* Fitch. The adult insects emerge in May, deposit their eggs on the surface of the growing plant, where they hatch in a short time, and the larva immediately penetrates the host. The author gives the life history of the insect, which extends throughout the following winter, and also gives the life history of the beetle (*Mordellistina unicolor* Lec.) which inhabits the gall, and a list of other insects found associated with the gall. It may be too much to expect the entomologist to give a discussion of the histology and development of the gall, but in connection with the study of the larva, it would certainly have added much to the paper if the author had given some attention to the host tissues to which the stimulation was applied.

An interesting paper is one by COBB[5] on a nematode disease of sugar cane and banana. The author calls attention to the outbreaks in Fiji, Hawaii, and Jamaica, describing the symptoms of the disease and the causal organism.

Another very valuable paper is by FELT,[6] who has made extensive studies of the gall midges in recent years. Although this paper is primarily entomological, it contains descriptions of many galls, some of which are rather difficult to classify.

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[4] CHI PING, Some inhabitants of the round gall of the golden rod. Jour. Ent. and Zool. **7**:161–179. 1915.

[5] COBB, N. A., *Tylenchus similis*, the cause of a foot disease of sugar cane and banana. Jour. Agric. Research **4**:561–568. 1915.

[6] FELT, E. P., A study of gall midges, III. 30th Report State Entomol. New York. Museum Bull. **180**:127–288. 1916.

Among the important foreign contributions is a paper by WADSWORTH[7] on the knapweed gall. This gall is most common on *Centaurea nigra* L., a very troublesome pasture weed, but also occurs *C. scabiosa* L., *C. montana* L., *C. paniculata* L., *Carduus nutans* L., *C. crispus* L., *C. anthoides* L., *Cirsium lanceolatum* L., *Serratula tinctoria* L., etc. The gall is caused by a dipterous insect which was originally described in 1758. The adults emerge during a period of about two weeks in June and deposit eggs on the young flower heads early in July. The author gives synonomy, historical discussion, description, life history, and distribution of the insect. The effect of this falling is to reduce the seed production to about 50 per cent. Of the seeds that are produced only 60.5 per cent germinate.—MEL. T. COOK.

Australian vegetation.—In a country of vast extent and consequent widely differing conditions it is difficult to gain any accurate concept of the most striking characters of the vegetation or of the principal affinities of the flora. Such a characterization was prepared by MAIDEN[8] in connection with the recent visit of the British Association to Australia. In reviewing the main natural divisions of the country he calls attention to the "geocols," broad depressed areas running east and west and separating wide plateaus, and to their possible influence upon plant distribution. Interesting botanical statistics show among other things that one family, the Leguminosae, is represented by 1275 species, while the Myrtaceae, Proteaceae, and Compositae show over 500 species each. Among remarkable prominent genera are *Acacia* with 412 species, and *Eucalyptus* with 230 species. Incidentally it would seem that the largest specimens of the latter of which authentic measurements exist are about 326 ft. in height and 25 ft. 7 in. in circumference, 6 ft. from the ground, dimensions excelled by the sequoias of America.

Some attention is given to introduced plants, many of which are of vast importance in the weed problems of the agricultural areas. The most remarkable instance cited is that of the prickly pear, *Opuntia inermis*, introduced from Rio de Janeiro in 1789 as food for the cochineal insect, which is now badly infesting an area of 30,000,000 acres, to which about 1,000,000 acres are being added annually by its natural increase.

The flora is analyzed rather effectively and its various affinities demonstrated. Finally, concise sketches are given of the flora and vegetational types of the various individual states. It is impossible to summarize these already condensed characterizations, but it may be of interest to note the attention directed to Victoria, the most carefully studied areas of which are

[7] WADSWORTH, J. T., Some observations on the life history and bionomics of the knapweed gall fly *Urophora solstitiallii* Linn. Annals Appl. Biol. 1:142–169. 1914.

[8] MAIDEN, J. H., Australian vegetation. Federal handbook on Australia. pp. 163–209. 1914. Issued in connection with the visit of the British Association for the Advancement of Science to Australia. 1914.

rich forests of the beech, *Fagus Cunninghamii*, and of the various species of *Eucalyptus*.

With the above it is interesting to compare the impressions of a visitor, as given by SAUNDERS[9] reporting the tour of the British Association in Australia. More detailed studies of limited areas are those of OSBORN and HARDY,[10] the latter giving an interesting account of a scrub vegetation termed "mallee," as it occurs in a portion of Victoria with 12–20 in. annual precipitation. This seems to be a semi-desert association of woody plants growing 6–10 ft. high, at times forming a rather open stand, but often almost impenetrable thickets. Shrubby species of *Eucalyptus* with vegetative habits of reproduction predominate with the almost leafless "broom mallee," *Exocarpus spartium*, upon sandy ridges.

OSBORN[11] describes the climatic conditions of the region about Adelaide which possesses a winter rainfall, 70 per cent of the total annual precipitation being between the months of May and October. Evidences remain that the plains upon which the city of Adelaide now stands were originally well wooded with various species of *Eucalyptus*, while the low sandy flats separating the plains from the sea show associations of the mangrove, *Avicennia officinalis*, and of shrubby species of *Salicornia*. Portions of the coast have in addition low sand dunes with grasses and shrubs. Notes upon other associations of the plains and mountains are also given, while not the least interesting is the brief study of the remarkable similarity of leaf forms existing in widely separated families, notably the sickle-shaped leaves of certain species of *Eucalyptus* and *Acacia*.—GEO. D. FULLER.

Meiotic divisions.—Owing to views put forward by LAWSON[12] as the result of an investigation of *Smilacina*, Miss WOOLERY[13] has investigated similar stages in a species of the same genus, and her conclusions do not agree in the main with those of LAWSON.

In the resting nucleus, the chromatin granules are found to be held in the meshes of a so-called fine linin network. This network, though perhaps not so extensive as it appears, is not altogether a fanciful structure. At no time in the early prophases was the individuality of the chromosomes apparent,

[9] SAUNDERS, E. R., The Australian meeting of the British Association. I. Botanical excursions. New Phytol. **14**:50–62. 1915.

[10] HARDY, A. D., The mallee: Ouyen to Pinnaroo. Victorian Nat. **30**:148–167. 1914.

[11] OSBORN, T. G. B., Notes on the flora around Adelaide, South Australia. New Phytol. **13**:109–121. 1914.

[12] LAWSON, A. ANSTRUTHER, The phase of the nucleus known as synapsis. Trans. Roy. Soc. Edinburgh **47**:591–604. 1911.

[13] WOOLERY, RUTH, Meiotic divisions in the microspore mother cells of *Smilacina racemosa* (L.) Desf. Ann. Botany **29**:471–482. 1915.

though this seems to be due partly to a misunderstanding of the term "maintenance of the individuality of chromosomes." The single spireme, which results from the fusion of chromomeres upon the linin thread, enters into the synaptic stage. In accord with LAWSON, Miss WOOLERY has found by measurements, which she records, that there is an enlargement of the nuclear cavity; but, contrary to the former's conclusions, the space occupied by the chromatin material is found by actual measurement, which she also records, to be less. During synapsis there is a shortening and a thickening of the thread to form the uniform spireme which later emerges from the synaptic ball. Unfortunately, there are no drawings to show the thread at the time of greatest contraction. During second contraction the first appearance of the split spireme is recorded, though the double structure spoken of in figs. 11 and 12 may possibly have been an earlier appearance of this condition. In several places considerable emphasis has been placed upon the fact that portions of the spireme are in connection with the nuclear membrane. The question would arise here, whether these were connections of any significance or merely portions of the chromatin that were tardy in movement. Reduction is by means of cross segmentation at the periphery of the radiating loops, as found during second contraction; this act being followed by a side-to-side approximation of the limbs of the loops or of separate portions of the thread, thereby forming the bivalent chromosomes. Evidences of spindle formation do not bear out LAWSON'S theory that the fibers are expressions of lines of tension due to the contraction of the nuclear membrane.

The idea that the resting nucleus is composed of two substances, chromomeres and linin, is still held by this investigator. Before definite conclusions can be drawn concerning the structure of the resting nucleus and the formation of the spireme from the resting condition, a closer series during the early prophases and the late telophase of the last division of the sporogenous tissue must be made. The careful measurements of the nuclear cavity and the chromatin mass at the time of the first contraction cannot fail to show fallacies in the view put forward by LAWSON.—MILDRED NOTHNAGEL.

Periodicity in mitosis.—In a paper on embryonal growth and its diurnal period, KARSTEN[14] deals with the periodicity of cell division. He calls attention to the fact that many algae shed zoospores in the early forenoon, and therefore must have undergone cell division during the night; and he cites the work of investigators who have shown positively that *Spirogyra*, *Zygnema*, diatoms, and desmids divide at night, most of them between 9:00 P.M. and midnight. He was not able to find similar records for the higher plants. The work of KELLICOTT[15] on the periodicity of mitosis in *Allium* was overlooked. KARSTEN

[14] KARSTEN, G., Über embryonales Wachstum und seine Tagesperiode. Zeitschr. Botanik **7**:1–34. 1915.

[15] KELLICOTT, W. E., The daily periodicity of cell division and of elongation in the root of *Allium*. Bull. Torr. Bot. Club **31**:529–550. 1904.

had already noticed that temperature affects the rate of cell division, and consequently he carried on his experiments in a large thermostat at a constant temperature of 25°. The most extensive investigation was made upon the root tips of seedlings of *Vicia Faba*. From 7:00 P.M. to 11:00 P.M. mitoses are slightly more frequent, and about 4:00 P.M. there is some diminution in the number. Roots of *Zea Mays* showed a uniform rate of mitosis throughout the 24 hours. Stem tips of seedlings of *Pisum sativum*, grown in the dark at a temperature of 25°, showed a larger number of mitoses between 9:30 P.M. and 1:30 A.M. By 3:00 A.M. the mitoses were much less frequent, and continued to diminish until the minimum was reached at 6:00 A.M. Stem tips of seedlings of *Zea Mays*, grown under the same conditions, begin to show an increase in the number of mitoses about 10:00 P.M. and a maximum is reached at 4:00 A.M., after which the number diminishes, reaching the minimum at about 8:00 A.M. When the stem tips were lighted from 6:00 A.M. to 6:00 P.M., by an electric light, the behavior was practically the same; but when they were lighted from 6:00 P.M. until 6:00 A.M. and kept in the dark from 6:00 A.M. until 6:00 P.M., the periodicity was accentuated; while continuous lighting made the periodicity less conspicuous.

The general conclusion is that, so far as mitosis is concerned, roots have no periodicity, but stems show it in a marked degree, with the maximum period in the night. It is evident that this investigation suggests further work by those who, like KARSTEN, have facilities for isolating and controlling factors. While so many observations have been made upon growth, and so many curves have been plotted, the literature does not seem to contain any curves for mitosis. Growth and cell division are two distinctly different phenomena which are often confused, or it might be more nearly correct to say that the cell division has been altogether disregarded.—C. J. CHAMBERLAIN.

Strobilus of Gnetum.—PEARSON[16] has made a careful study of the puzzling inflorescence of the Gnetales, and has added much to our knowledge of the facts. Not only have the structures involved been confusing, but the terminology as well, for how to apply the terms strobilus and flower has been perplexing. Calling the unit structure a "flower," and the whole cluster therefore an "inflorescence," the following statement of PEARSON'S results may be made. He finds that wide differences occur within the same species in the number of staminate flowers produced in basipetal succession at each node, in *G. scandens* the number of such flowers in a single inflorescence sometimes being as many as 3000. The "antherophore" apparently elongates rapidly just before dehiscence of the anthers, freeing them from the envelope. In *G. Gnemon* the staminate inflorescence "usually bears one or more complete female flowers," and in some material these ovulate flowers are more abundant in oldinflores cences, from which some or all of the staminate flowers have fallen. In *G. scandens*,

[16] PEARSON, H. H. W., A note on the inflorescence and flower of *Gnetum*. Ann. Bolus Herbarium 1:152–172. *pls. 24–26*. 1915.

on the other hand, incomplete ovulate flowers, which are very small and always concealed by the staminate flowers, occur in the staminate inflorescence. It is suggested, therefore, that *G. scandens* represents a reduction stage of ovulate flowers in an inflorescence which is becoming staminate, a pure staminate inflorescence being reached in *G. africanum* and *G. Buchholzianum*. Naturally this situation suggests that the present monosporangiate inflorescence of *Gnetum* has been derived from a bisporangiate inflorescence. It is suggested further that the ovulate inflorescence was probably derived "by the arrest of the nodal meristem by which the later formed staminate flowers are produced." Since a terminal ovulate flower is of common occurrence, such a flower replacing the barren tip of the axis, it is suggested that the primitive inflorescence consisted of "an axis bearing a cupule, a ring of male flowers, and a terminal female flower or a group of which one is terminal," which is certainly suggestive of the strobilus of the Bennettitales. Further evidence is presented to indicate that the staminate flower, commonly thought of as a reduced staminate strobilus ("anthostrobilus"), probably has no such relationship.—J. M. C.

Plant pathology in the tropics.—Those who have followed this branch of botany must be impressed by the large amount of work accomplished in the past five years. In an interesting paper by ASHBY[17] we find a discussion of (1) bud diseases of the coconut, in which the author expresses the opinion that the bud rot attributed by JOHNSON (U.S. Bur. Pl. Ind. Bull. 228) to *Bacillus coli* may be due also to other species of bacteria; other species found associated with the bud rot were connected to the type groups *B. carotovous*, *B. aerogenes*, and *B. typhi;* (2) a bud decay of the coconut caused by *Thielaviopsis paradoxa*, which is also the cause of diseases of bananas, sugar cane, pineapple, and stem of the coconut; (3) another bud decay apparently caused by a species of *Phytophthora;* (4) several leaf diseases due to *Diplodia cocoicos* Cooke, *Pestalozzia palmarum* Cooke, and other fungi; (5) several other fungous diseases of the root and stem of the coconut; (6) diseases of the cocoa; (7) diseases of the banana; (8) diseases of the orange. The author gives good descriptions of the diseases and of the organisms.

The Department of Agriculture of Jamaica has issued a bulletin on "Diseases of plants," in which are given laws in regard to the introduction and spread of plant diseases, and orders concerning the "Panama disease" or "wilt" of the banana. This is followed by a description of the disease which causes a breaking down of the leaves, with or without previous yellowing, beginning with the oldest. The trunk is sometimes split and the fruit ripens prematurely and is dry, pithy, and without flavor. Internally will be found many dark red streaks extending from the base upward through stems and leaves. This condition is followed by a stinking soft rot. The disease is attributed to a *Fusarium*, very similar in morphology and habit to *F. vasinfectum* Atk. It is

[17] ASHBY, S. F., Notes on diseases of cultivated crops observed in 1913–1914. Bull. 8, Dept. Agric. **2**: 299–327. 1915.

a soil organism which gains entrance through wounds and readily passes from the parent plant to the suckers. It spreads by diseased plants, infected soils, by farm implements, and on the clothing and boots of the laborers.—MEL. T. COOK.

Permeability.—STILES and JORGENSEN[18] have measured the effect of temperature on the rate at which hydrogen ions of hydrochloric acid are absorbed by the tissue of potato tuber. Disks of potato tubers 1 cm. in diameter, weighing about 0.5 gm., were immersed in HCl of concentration 0.0011 N. This low concentration was used in order to avoid injury to the tissue. Experiments were carried out at temperatures of 0° C., 10° C., 20° C., and 30° C. At intervals up to 8 hours the quantity of the hydrogen ions absorbed was measured by determining the loss of hydrogen ions in the bathing solution. The hydrogen ion content of the latter was measured by a hydrogen electrode, a description of which the authors give.

The rate of absorption was increased by a rise of 10° C. as follows: from 0° to 10°, 2.22 times; from 10° to 20°, 2.17 times; from 20° to 30°, 2.18 times. This is in agreement with the Van't Hoff law for the effect of temperature upon the rate of chemical reaction, and the authors conclude that "the study of the effect of temperature on the absorption of the hydrogen ion would seem to indicate that the absorption is controlled by some chemical action in the cell, and is not the result of simple diffusion through the plasma membrane, or of mere absorption by the cell protoplasm." Their view is that the acid reacts with some substance in the potato, that this substance is either present in large quantity as compared with the amount of acid fixed, or that the resulting compound is broken down again almost as soon as formed. As to the identity of the substance that reacts with the acid, they state it is "presumably the plasma membrane, or some part of it." The reviewer is not convinced yet, however, that in their experiments they were dealing primarily with the permeability of the plasma membrane. The title of the paper expresses the situation more exactly.—F. E. DENNY.

The humidity of a ravine.—It has long been commonly accepted that both the atmospheric humidity is greater and the supply of soil moisture more abundant in a narrow ravine than upon the adjacent upland, but no quantitative data have been available to confirm these observations. To supply these deficiencies ULLRICH[19] measured the evaporating power of the air at 15 different points in a clay ravine, and determined the range of soil moisture for a corresponding number of stations for a period of four months, from the beginning

[18] STILES, WALTER, and JORGENSEN, INGVAR, Studies in permeability. II. The effect of temperature on the permeability of plant cells to the hydrogen ion. Ann. Botany **29**:611–618. *figs. 4.* 1915.

[19] ULLRICH, F. T., The relation of evaporation and soil moisture to plant succession in a ravine. Bull. Ill. State Lab. Nat. Hist. **12**:1–16. *pl. 18.* 1915.

of July 1913. The results of both series of determinations are plotted graphically, and furnish many interesting details regarding the conditions for plant life in such a habitat. The variations in soil moisture, although considerable, do not indicate that this is the factor of most importance in promoting the greater mesophytism of the ravine habitat as compared with the upland. Evaporation differences show more contrast in these two habitats, as may be shown by a few examples. The average daily rates of evaporation from the standard atmometer for the open upland, the forested upland, the south-facing slope, the north-facing slope, and the bottom of the ravine were respectively 16.3, 8.7, 7.9, 6, and 4.7 cc. This shows very definitely that the more or less confined atmosphere of the lower parts of rather narrow ravines has frequently only about one-half the evaporating power possessed by more freely circulating air of the forested upland. Maps of the region north of Chicago in which the ravine is located and of the ravine itself, together with the tabulation and plotting of data and photographs of the vegetation at the various stations, add to the value of the paper.—GEO. D. FULLER.

New Zealand vegetation.—A non-technical but truly scientific description of the vegetation of any land is interesting and useful, even to botanists, in forming a general concept of the plant growth of that region. In such an article COCKAYNE[20] has sketched the flora of New Zealand, and has managed to include many facts within the limits of a few pages. Analyzing the composition and affinities of the flora, he finds 74 per cent endemic, while Malayan, Australian, and subantarctic elements follow in decreasing importance, and the final touch is given by a remarkable element composed of species either closely related to or identical with those of the northern hemisphere.

Among the various plant communities characterized are the rain forest, the southern beech forest, the tussock steppe, the swamp, and the subalpine fell-field. The first of these originally covered all the lowland and montane regions of North Island, and considerable portions of the west and south of South Island. This rain forest was remarkable for the abundance of conifers in such genera as *Dacrydium*, *Podocarpus*, and *Agathis*, mingled with broad-leaved evergreens, woody climbers, ferns, mosses, and liverworts in luxuriant profusion. Very different from the rain forest, but quite as distinctive, was the tussock steppe, dominated by large grasses of the tussock habit of growth. The principal species were *Danthonia Raoulii*, *Poa caespitosa*, and *Festuca novae-zealandiae*. Somewhat less attention is devoted to the beech forest with five species of *Nothofagus*, the heath thickets, swamps, sand dunes, and mountains; while the article closes with some statistics of plant families, genera, and species.—GEO. D. FULLER.

[20] COCKAYNE, L., The primitive vegetation of New Zealand. Jour. Agric. (New Zealand) **9**:401–410. 1914.

Taxonomic notes.—MIYABE and KUDO[21] are investigating and recording material for a flora of Hokkaido, Japan, and five small fascicles have been published. In these fascicles 60 species are presented, new species being described in *Luzula*, *Eriophorum*, *Tofieldia* (3), and *Dactylostalix* (an orchid). In addition to new species there are several new names and combinations.

MIYAKE[22], in connection with a study of fungi from China, includes in his published list of 56 species descriptions of 4 new species of Fungi Imperfecti, representing the following genera: *Coniothyrium*, *Melophia*, *Marsonia*, and *Cercospora*.

MAKINO,[23] in continuation of his studies of the flora of Japan, has published new species in *Scleria* (2) and *Utricularia*.

BLAKE[24] has described the following new genera of Compositae, chiefly Mexican: *Haplocalymma* (based on *Viguiera microcephala* Greenm.), *Phoebanthus* (to include *Helianthella grandiflora* T. and G. and *H. tenuifolia* T. and G.), and *Pionocarpus* (based on *Helianthella madrensis* Wats.); and also new species in *Gymnolomia*, *Viguiera* (2), *Perymenium* (3), and *Chrysactinia*.

ROBINSON[25] has described new species from Cuba, Mexico, and Guatemala in *Eupatorium* (5), *Brickellia*, *Verbesina*, and *Liabum*, in addition to new varieties, forms, names, and combinations.

MACBRIDE,[26] in connection with a study of the Borraginaceae of the Gray Herbarium, has found it necessary to make a number of new names and combinations, and has also described two new species of *Heliotropium*, both from Mexico.—J. M. C.

Morphology of Treubia.—CAMPBELL,[27] studying material of *Treubia insignis* collected at the original station near Tjibodas on Mount Gedeh, Java, finds that the archegonia, which occur in groups up to a dozen, have as many as 9 neck cells; that there is no clear line of demarcation between the deck and the ventral region; and that as many as 8 neck canal cells are sometimes present. GRÜN, studying the same form, reports as many as 16 neck canal

[21] MIYABE, K., and KUDO, Y., Materials for a flora of Hokkaido. Pts. 2, 3, 4, 5. Trans. Sapporo Nat. Hist. Soc. **5**:37–44, 65–80, 145–152; **6**:1–9. 1915.

[22] MIYAKE, I., Studien über chinesische Pilze. Bot. Magazine **27**:45–54. 1913.

[23] MAKINO, T., Observations of the flora of Japan. Bot. Magazine **27**:55–60. 1913.

[24] BLAKE, S. F., Compositae new and transferred, chiefly Mexican. Proc. Amer. Acad. **51**:515–526. 1916.

[25] ROBINSON, B. L., New, reclassified, or otherwise noteworthy spermatophytes. Proc. Amer. Acad. **51**:527–540. 1916.

[26] MACBRIDE, J. FRANCIS, Certain Borraginaceae, new or transferred. Proc. Amer. Acad. **51**:541–548. 1916.

[27] CAMPBELL, DOUGLAS HOUGHTON, The archegonium and sporophyte of *Treubia insignis* Goebel. Proc. Nat. Acad. **2**:30–31. 1916.

cells. The lack of demarcation between neck and venter, always notable in Jungermanniales, is here most pronounced. This character, taken in connection with the large number of neck canal cells, seems to suggest that the archegonium is primitive; that while other structures have made rapid strides forward, the archegonium has stood still, relatively speaking. The earliest stages of the embryo were not seen, but in the youngest stage a prominent haustorium, derived most probably from the hypobasal half of the fertilized egg, was present. The foot is not sharply delimited from the seta; this is, of course, a primitive character. The wall of the capsule is 3-layered and the apex is thickened into a pronounced beak, an advanced condition phylogenetically. CAMPBELL considers that *Treubia* is nearer the acrogynous liverworts than is any other anacrogynous form.—W. J. G. LAND.

Botanical microtechnique.—SMITH[28] gives a résumé of botanical microtechnique from the time of HOOKE to the present time, and treats the subject under three heads: from HOOKE to 1800; the technique of the English microscopists and the German botanists from 1800 to 1875; modern microtechnique from 1875 to the present time. For the first time the pioneer work of JOHN HILL has received the recognition it merits. HILL was one of the very few workers in botany during the exceptionally barren eighteenth century, and many of his methods were "rediscovered" after nearly 75 years. HILL successfully used maceration methods, and in a crude way fixed and hardened his material. He is beyond doubt the first botanist to use staining as an aid to determine structure, the stain being an alcoholic tincture of cochineal. He also understood and used mordants, injected vessels by boiling pieces of wood in green sealing wax, cut sections on a microtome, and cleared them in spirits of turpentine. The credit of first using paraffin for interstitial imbedding is given to FRANCOTTE, that of soap to PFITZNER, and that of celloidin to BUSSE. The history and evolution of the microtome is traced from 1770 to the present time, but no mention is made of the marvelously accurate rotary microtome which has succeeded that of MINOT.—W. J. G. LAND.

Influence of nutrition on development of sex organs.—NAGAI[29] has investigated the influence of nutrition on the development of the sex organs of *Osmunda regalis japonica* and *Asplenium Nidus*. Previously he had shown that factors of environment play important rôles in the sexual development of the gametophytes of *Ceratopteris thalictroides* and other ferns.[30] In the present

[28] SMITH, GILBERT MORGAN, The development of botanical microtechnique. Trans. Amer. Microsc. Soc. **34**:71–129. *figs. 18*. 1915.

[29] NAGAI, ISABURO, On the influence of nutrition upon the development of sexual organs in the fern prothallia. Jour. Coll. Agric. Univ. Tokyo **6**:121–164. *pl. 10. figs. 7*. 1915.

[30] NAGAI, ISABURO, Physiologische Untersuchungen über Farnprothallien. Flora **106**:281–330. 1913.

investigation he has attempted to show quantitatively the influence of nutrition. In the two ferns investigated, he found that the development of the two sex organs could be controlled by certain concentrations of Knop's solution. In general, the number of antheridia decreases as the concentration decreases. In both species archegonia are formed only above 0.175 per cent Knop's solution, which was the optimum concentration for *Asplenium;* but 0.35 per cent was the optimum for *Osmunda*. In many of the prothallia of *Asplenium* the two sex organs appeared only successively. The prothallia of *Osmunda* remained almost completely sterile when grown in solutions lacking calcium or magnesium salts. Numerous combinations of conditions were used, with varying results, and the evidence all indicated that the production of sex organs is a response to factors in the environment.—J. M. C.

Indiana Academy.—The Proceedings of the Indiana Academy of Sciences for 1914 contains the following contributions of interest to botanists: An apparatus for aerating culture solutions, by PAUL WEATHERWAX; Antagonism of *B. fluorescens* and *B. typhosus* in culture, by P. A. TETRAULT; Notes upon the distribution of forest trees in Indiana, by STANLEY COULTER; Mosses of Monroe County, Indiana, by MILDRED NOTHNAGEL and F. L. PICKETT; A new enemy of the black locust, by GLENN CULBERTSON; A new leaf spot of *Viola cucullata*, by H. W. ANDERSON; Oat smut in Indiana, by F. J. PIPEL; Plants new or rare to Indiana, by C. C. DEAN; Some peculiarities in *Spirogyra dubia*, by PAUL WEATHERWAX; Report on corn pollination, by M. L. FISHER; Stomata of *Trillium nivale*, by F. M. ANDREWS; The primrose-leaved violet in White County, by L. M. HEIMLICH; Continuous rust propagation without sexual reproduction, by C. A. LUDWIG; Correlation of certain long-cycled and short-cycled rusts, by H. C. TRAVELBEE; Some species of *Nummularia* common in Indiana, by C. E. O'NEAL; The genus *Rosellinia* in Indiana, by G. B. RAMSEY; Some large botanical problems, by J. C. ARTHUR.—J. M. C.

A new genus of Bennettitales.—THOMAS[31] has described a new genus of Bennettitales (*Williamsoniella*) based upon material obtained from mesozoic beds in Yorkshire. It is represented by buds, mature strobili ("flowers"), microsporophylls, and the ovulate portions of the strobili. The strobilus is bisporangiate and very small, with no ensheathing sterile bracts; 12–16 wedge-shaped microsporophylls, each bearing 4–6 synangia; sessile ovules, "very similar in external appearance to the interseminal scales"; and the sterile tip of the strobilus axis terminating in "a characteristic corona-like structure" (which suggested the specific name, *W. coronata*). In all probability these strobili were borne in the forks of dichotomously branching stems, whose leaves had been known as *Taeniopteris vittata*. A "flower bud," thought to belong to the same genus, is named *W. roseberriensis*. The marked features

[31] THOMAS, H. H., On *Williamsoniella*, a new type of Bennettitalean flower. Phil. Trans. Roy. Soc. London B **207**:113–148. *pls. 12–14.* 1915.

of this new form, as compared with the long-known forms, are the simple microsporophylls and sessile ovules. The author concludes that there is no evidence of any connection between Bennettitales and angiosperms.—J. M. C.

Atmometry and the porous cup.—With the increasing attention now being given to the quantitative determination of ecological factors, it is fortunate to have the technique of one of the most fruitful fields of investigation reviewed and summarized by the worker most prominently connected with it from the beginning. Such a review of the instruments and methods of measuring the evaporating power of the air by LIVINGSTON[32] has recently appeared, including descriptions of the various forms of atmometers and their operation and standardization. Prominent among the recent improvements in this field is the rotating table for standardizing the porous cups, already noted in this journal,[33] and the improved form of the non-absorbing porous atmometer devised by SHIVE[34] to provide against errors caused by the absorption of water by the atmometer during rainfall. The various difficulties encountered by LIVINGSTON and other workers during the ten years since he invented the present form of porous cups are discussed in a way that makes the work invaluable to all workers in this field.—GEO. D. FULLER.

Evaporation in a marsh.—In a marsh upon the borders of Lake Erie, where zonation was well marked, SEARS[35] has measured the rate of evaporation in the different associations for a period of four weeks following June 29, and found the highest rate above the open water in the *Scirpus* association, with the lowest in one dominated by *Calamagrostis canadensis*. The comparative values for associations dominated by *Calamagrostis*, *Typha*, *Phragmites*, *Pontederia*, *Sparganium*, *Castalia*, and *Scirpus* are correspondingly 100, 102, 113, 125, 137, 343, and 413. It is to be regretted that the observations did not extend over a longer period, and that SEARS has not reduced his results to the unit commonly used by other workers in this field, that is, to loss per day from the standard atmometer. However, it is an important addition to the data now gradually accumulating of the evaporating power of the air in various habitats.—GEO. D. FULLER.

Rachiopteris.—Miss BANCROFT[36] describes a large amount of material from various sources, which is referred to *Rachiopteris cylindrica*. Two types

[32] LIVINGSTON, B. E., Atmometry and the porous cup. Plant World **18**:21–30, 51–74, 95–111, 143–149. 1915.

[33] Bot. Gaz. **55**:263. 1913.

[34] SHIVE, J. W., An improved non-absorbing porous cup atmometer. Plant World **18**:7–10. 1915.

[35] SEARS, P. B., Evaporation and plant zones in the Cedar Point marsh. Ohio Jour. Sci. **16**:91–100. *figs. 5*. 1916.

[36] BANCROFT, N., Contributions to our knowledge of *Rachiopteris cylindrica* Will. Ann. Botany **29**:531–565. *pls. 26, 27*. 1915.

of branches, the *alpha* type and the *beta* type, are noted. The former are more vigorous, and the latter slender and with a lacunar cortex. The author connects these types with one another as part of the same individual, regarding the slender ramifications as possibly adapted to aquatic conditions. The organization of the vascular tissues is protostelic, characterized as exhibiting a central core of small, entirely tracheary tissue surrounded by an envelope of larger elements of the xylem. The author calls attention to the support furnished by *Rachiopteris* for the hypothesis put forward by BOWER, POTONIÉ, and others, for the branchlike origin of the leaf in ferns and their allies.—E. C. JEFFREY.

The grass embryo.—SARGANT and ARBER,[37] studying seedlings, and embryos of grasses at the dormant stage, find many variants within the family, which can be satisfactorily accounted for by deriving them from a hypothetical form. This imaginary form they designate as *X*, and the relationships of the various embryos and seedlings are worked out with much ingenuity. The reviewer believes that the problem of the actual relations of monocotyledons to each other and also to the dicotyledons will not be solved by erecting a hypothetical form, but that real progress can be made by a critical study of the earlier stages of the embryo, extending from the fertilized egg to the dormant stage of the embryo. A study of the literature of the subject shows how little is actually known of early embryogeny in angiosperms.—W. J. G. LAND.

Medullary phloem.—A recent paper by WORSDELL[38] is of considerable interest because it involves the deliberate application of general anatomical principles derived from the study of the gymnosperms, living and extinct, to the elucidation of the anatomical structure of the dicotyledons. Its author, as a result of a sojourn in South Africa, became possessed with a large amount of material of the Cucurbitaceae, a group well developed in this geographic region. He finds good reason for concluding from the study of the conservative peduncular and petiolar regions that internal phloem, a feature of the family, is not a primitive characteristic, but results from the fusion of inverted medullary strands with the inner surface of a normal cycle of bundles. Further studies from the same quarter will be awaited with interest.—E. C. JEFFREY.

Potamogeton.—While the economic aspect of the growth of various species of *Potamogeton* in ponds has been the prime object of investigation, Miss MOORE[39] has presented valuable data upon the habits of growth and reproduc-

[37] SARGANT, ETHEL, and ARBER, AGNES, The comparative morphology of the embryo and seedling in the Gramineae. Ann. Botany **29**:161–222. *figs. 35. pls. 9, 10.* 1915.

[38] WORSDELL, W. C., The origin and meaning of medullary (intraxylary) phloem in the stems of dicotyledons. I. Cucurbitaceae. Ann. Botany **29**:567–590. *figs. 10.* 1915.

[39] MOORE, EMMELINE, The Potamogetons in relation to pond culture. Bull. Bur. Fisheries **33**:255–291. *pls. 22–39.* 1915.

tion in these plants. Emphasis is laid upon the propagation by tubers, tuberous rootstocks, winter buds, burs, and by fragments of stems. The economic aspect of the genus is inseparable from the ecology of the pond, for it deals principally with the food supply afforded a large number of animals, ranging from the larvae of Diptera to canvasback ducks. The paper is made more valuable by its numerous plates and by an extensive bibliography.—GEO. D. FULLER.

Marine algae in fresh water.—Experimenting with several species of marine algae, Miss BROWN[40] found that many soon died and disintegrated if placed in fresh water, or even in sea water with a larger admixture of fresh water. Other species, and notably *Enteromorpha intestinalis*, not only endured almost pure fresh water for a period of about 4 weeks, but also seemed to grow more rapidly in waters fresher than those of the sea. The factors involved in this tolerance were not further analyzed.—GEO. D. FULLER.

Thelephoraceae.—In continuing his studies of the Thelephoraceae of North America, BURT[41] presents *Exobasidium*, *Tremellodendron*, *Eichleriella*, and *Sebacina*, with a full historical discussion, synonymy, and citation of stations. The data in reference to the species are as follows: *Exobasidium*, 3 species; *Tremellodendron*, 7 species (2 new species and 3 new combinations); *Eichleriella*, 5 species (2 new species and 3 new combinations); *Sebacina*, 14 species (7 new species and 4 new combinations).—J. M. C.

Species of Carex.—MACKENZIE,[42] in continuing his studies of *Carex*, discusses *C. straminea* and some of its nearest allies, and also describes 8 miscellaneous new species, chiefly western, as follows: *C. festivella*, *C. Egglestonii*, *C. Lunelliana*, *C. bulbostylis*, *C. onustra*, *C. Sheldonii*, *C. exserta*, and *C. rugosperma*.—J. M. C.

Polyporaceae.—OVERHOLTS[43] has investigated certain critical forms of Polyporaceae, discussing characters and technique, and presents his conclusions in definitions of the 22 species considered.—J. M. C.

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[40] BROWN, LOLA B., Experiments with marine algae in fresh water. Puget Sound Marine Sta. Publ. 1:31–34. 1915.

[41] BURT, EDWARD ANGUS, The Thelephoraceae of North America. IV and V. Ann. Mo. Bot. Gard. 2:627–658. *pl. 21;* 731–770. *pls. 26, 27.* 1915.

[42] MACKENZIE, K. K., Notes on *Carex*. IX. Bull. Torr. Bot. Club 42:603–621. 1915.

[43] OVERHOLTS, L. O., Comparative studies in the Polyporaceae. Ann. Mo. Bot. Gard. 2:667–730. *pls. 23–25.* 1915.